JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA

FOR THE PROMOTION OF THE MECHANIC ARTS

VOL. CLXVI, No. 3 83RD YEAR SEPTEMBER, 1908

The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal*.

THE FRANKLIN INSTITUTE.

(Stated meeting held Wednesday, April 15, 1908.)

The Theory of Shooting and the Evolution of the Spitzer Bullet.

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A knowledge of the fundamental laws governing the flight of the bullet fired from a rifle—the theory of shooting—while it is a necessity for the gun-makers and the gun-experts, ought to be also possessed by every shooter. The person possessing this knowledge, all other things being equal, will be superior in marksmanship to the one not acquainted with these fundamental laws. A proper teaching of the theory of shooting ought to be the foundation upon which to develop the greatest percentage of marksmen—of good shots.

The flight of the bullet from the muzzle to the point in its flight, where it loses the power imparted to it by the explosion of

the powder, is called trajectory. The length of the trajectory, in the main, is determined by the relative proportion of the weight of the projectile to the strength or expansive power of the developed powder gases. The bullet loses its power after leaving the muzzle, first "by the law of gravity," and second, by "the resistance of the air."

In order to overcome, or rather counter-effect the fall of the bullet, we elevate the muzzle by means of the difference in elevation of front and rear sight. The second we try to minimize, as much as possible, by rifling the barrel and shaping the bullet.

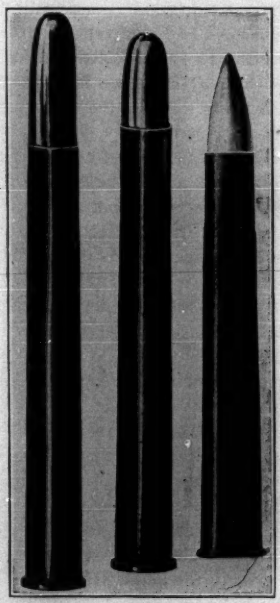
The law of gravity is a well known quantity. The bullet, from the moment it leaves the muzzle, falls at the square of the odd numbers; that is, it falls 16 feet, approximately, in the first second, it falls 3×16 feet in the second second, it falls 5×16 feet in the third second. Consequently, if we did not elevate the muzzle over the horizontal line, we would have to fire the rifle from a height of sixteen feet in order to hit a point perpendicularly below on the ground at the end of the first second of the flight of the bullet. In order to hit the same point at the end of the second second of the flight of the bullet, we would have to mount a scaffold $3\times16+16=64$ feet in height. At the end of the third second the scaffold would have to be $5\times16+64=144$ feet in height. This shows the necessity of accelerating the flight of the bullet as much as possible. Upon the space traversed in the first second, which we call the initial or muzzle velocity of the bullet, depends, in a large measure, the efficiency of the bullet.

To overcome the effect of gravitation upon the bullet, we elevate the muzzle by making the rear sight higher than the front sight. This creates an angle between the line of sight, formed by the eye on one end and looking in a straight line over the rear sight and front sight with the point aimed at at the other end, and the imaginary line drawn through the exact center of the barrel and elongated. The projectile follows this imaginary line just as long as it is in the barrel, but the very moment it leaves the muzzle the law of gravitation acts upon it and it falls, that is, it leaves the continuation of the imaginary center line of the barrel. The angle between the line of sight and the center line is formed the nearer to the muzzle of the rifle the higher the elevation of the rear sight.

The trajectory takes the form of an elongated, parabolic-curve,

which can be aptly illustrated by the outline of a hen's egg cut in half. The trajectory is divided into two parts, the one nearer to the muzzle being called the ascending arm, the one nearest the point aimed at the descending arm. The ascending arm forms about two-thirds of the length of the trajectory.

There is but one trajectory, and that is the one at the distance



No. 1. No. 2. No. 3.

where the bullet ceases to have any power except the power of its own weight. This is important to keep in mind, for, whether we speak of a trajectory at 50 yards, at 150 yards or at 1000 yards, they are all a part of the same long trajectory only produced by stopping the flight of the bullet by an object interposed at a certain point in this never-varying flight.

The ascending arm of the trajectory rises to a certain point over the line of sight at a given distance and this highest point is

called the elevation. In speaking of a high or low trajectory we mean the highest point of that trajectory over the line of sight. The parts of the trajectory where the elevation is not greater than the size of the object aimed at is called the "danger zone." If, for example, you aim at a deer standing still, you have to judge the distance. We will say you judge this distance to be 150 yards. If you have a rifle where the elevation of the trajectory is 24 inches, you will have to judge very accurately, for if that deer happens to stand at 120 yards instead of at 150 yards, you are very apt to miss him by overshooting, or, if he stands at 170 yards, by undershooting. If, on the other hand, you have a rifle with a low or flat trajectory, say, for example, of nine inches elevation, you will hit that deer at any distance from you up to 150 yards, providing you aim at the belly part of the body, a deer presenting a killing surface of about ten inches.

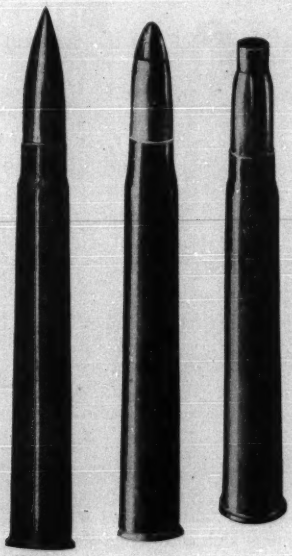
The practical solution of the effect of the law of gravity upon the bullet is, as we have seen, easy. The practical overcoming of the resistance of the air is an entirely different and much more difficult matter. In my introductory remarks I said that we try to overcome the resistance of the air by rifling the barrel and shaping the bullet.

The first projectile of which we have any knowledge is a round ball of lead, whose sphere fitted the bore of a smooth barrel. If the ball did not fit, it was patched by a piece of greased cloth.

It was soon evident that, in order to produce results, we had to impart to the bullet a boring motion and also make it as light as possible. But in putting a twisted rifling into the barrel, while we imparted a screw-like motion to the bullet during its flight through the air and thereby enabled it to overcome the resistance better, we also greatly intensified the effect of the bullet's own center of gravity upon its flight. This effect of the center of gravity upon the flight of the bullet has forever been the bugbear of riflemakers. It threads its way through the whole history of the bullet, from its inception in the round ball to the present pointed bullet.

At first there was no proviso for upsetting the ball in the barrel, the ball being seated directly on the powder. The least irregularity in the sphere of the ball would let powder gases escape alongside of it. It is of common occurrence to-day for a gunmaker to be called upon to take the breech-pin out of a barrel

and find it nothing but a plug against which powder and ball rested, with just a vent for the entrance of the flash produced by the explosion of the powder in the pan or the percussion cap. The next step forward was the elongation of breech-pin so as to contain a receptacle for the powder with a rounded concave place for the ball. By seating the ball firmly with the ramrod it would spread until stopped by the sides of the barrel and thus produce an even fit.



No. 4. No. 5. No. 7.

This principle was employed until the breech-loading rifle superseded the muzzle-loader. The first known were straight grooves cut lengthwise into the barrel; this was done to enable the shooter to use both shot and ball in the same weapon. But the guiding power of the rifling upon the ball was very small on account of the small amount of contact between a round ball and the barrel; and the ball, after leaving the muzzle, would play all

kinds of pranks in finding its own center of gravity or equilibrium.

When we think that these balls were all cast in a mould, that this mould would enclose an amount of air, part of which would invariably be imprisoned in the wall without any way to determine where it was; when we think that in a ball, twelve to the pound, and which is a little over three-fourths inch in diameter, this air-hole might be clear to one side, you can readily imagine the funny motions of that ball in the air when it jumps around this eccentric-hole in the inside.

The uselessness of the ball was too apparent for it not to be soon abandoned.

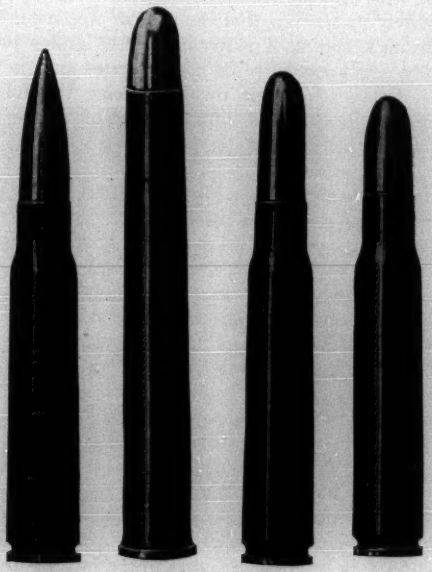
In order to make the rifling effective it was necessary to create more contact; this led to the elongated ball—the bullet—and the diminution of the bore or calibre. If we talk of a bore we mean a barrel, the diameter of which is adapted to a ball, a given number of which make a pound in weight; if we talk of caliber we mean a barrel the diameter of which is expressed in inches. It is therefore proper to say, "A 12-Bore Gun" and "A 32-Cal. Rifle."

Shot-guns are made in bores from 4-bore to 28-bore, also called gauge; that means that the diameter of the true sphere of a ball weighing one-quarter pound or four ounces means a 4-bore or gauge, while the same relative measurements obtaining to twelve balls in a pound would mean 12-bore or gauge, etc. The diameter of the true sphere of a 12-bore gun-barrel is .729 inches.

But the elongated bullet, while it offered a smaller front for the action of the air, still was just as freaky as the ball, for that little aforementioned air-hole might be in the extreme end of it, and the bullet, instead of flying straight, would describe a series of somersaults in the air, alongside of which the performances of Barnum's best clowns sink into insignificance.

The desire to force the bullet to fly in the direction imparted to it by the barrel created the twisted rifling. A great step forward had been accomplished, for not only had the gunmaker succeeded in forcing the bullet to revolve around its own axis, and thereby minimize the effect of the center of equilibrium, but the resistance of the air was materially reduced, especially as the improvements in the methods of rifling allowed the reduction of the weight and the diameter of the bullet. With the introduction of the stud into the breech-pin the maximum of efficiency in muzzle-loading

rifles was reached. This stud was a pin screwed into the exact center of the breech-pin and entering for the length of about 1½ inches into the barrel. The flat end of the bullet would meet this stud, and by tapping with the ram-rod, would spread the bullet to fill out the grooves evenly. The open space between the bullet and the end of the breech-pin allowed the powder charge



Nos. 11, 12 & 13. Nos. 3 & 4. No. 6. Nos. 8 & 10.

to be changed *ad libitum*. This method, however, was only adopted where there was ample time for loading, and was therefore employed mainly for target-rifles. The degree of accuracy, however, obtained by these rifles up to 400 yards is astonishing.

We now enter the era of the breech-loader. When Dreyse, of Locmerda, Germany, invented the needle-gun, the muzzle-loading rifle had been developed to a high degree of efficiency, and the theory of shooting was well known to this inventor. His m' in

aim was to overcome the unevenness in the burning of black powder. For when black powder is ignited from the rear end of the powder volume, its ignition being slow, it develops sufficient gases to drive the bullet out of the barrel before all the powder had been ignited. The injurious effect of this uneven ignition upon the accuracy of flight of the bullet is apparent. In the muzzle-loading rifle with the breech-pin stud this had been overcome almost entirely by the fact that the powder was lying loose in a sort of chamber, and, as a matter of course, ignites quicker and more evenly. But powder could not be carried loose in fixed ammunition. Dreyse overcome this by placing the fulminate in front of the powder column, in the center of a paper cylinder, which was about one inch in length, and the other end of which formed a cavity which contained the bullet. This bullet was elongated with round ends, the front end being slightly more pointed. This bullet being smaller than the caliber of the rifle, never touched the inside of the barrel, but received its impetus from the paper cylinder. The needle penetrated the powder column the whole length, and pricking the fulminate, ignited it. As there was no chance for any powder not to burn before the bullet left the muzzle, the accuracy of this weapon at short range was very great, in fact, at short range it has never been surpassed by any rifle shooting a cartridge loaded with black powder. But at ranges over 300 yards the bullet went wild. On account of the shell being made out of paper, however, this style of cartridge never found much favor in either military or sportsmen's circles outside of Prussia.

An enormous stride forward has been made; we had the breech-loading rifle, and soon came the brass shell. As a matter of curiosity it may be remarked, that in the infancy of the brass shells a great many gunmakers shook their heads dubiously, for results with these shells were not easily obtainable, on account of the fact that a new factor had to be taken into consideration. For, following the physical law of the mutability of bodies, the bullet would upset; that is, on account of the suddenness of the shock, the front part of the now well elongated bullet would be still while the rear part was already in motion. This same effect is produced, for example, on a center-punch or a chisel in the upsetting of the head. In the muzzle-loading rifle this did not have any effect, for the bullet was contained by the rifling; but in

a breech-loader this at first proved a serious drawback, for the exact size of the bullet was not easily obtainable. Many a first-class rifle-maker has given up the making of breech-loading rifles in despair; a few of them, however, helped themselves in a curious way. They would make a steel shell; the inside of this shell was smaller than the caliber of the rifle and projected into the rifle in exactly the same manner as in the muzzle-loading rifle. The bullet was inserted from the muzzle, usually with the help of a false muzzle, and with a ram-rod seated on the projection of the steel shell. It is noteworthy that this same method is employed

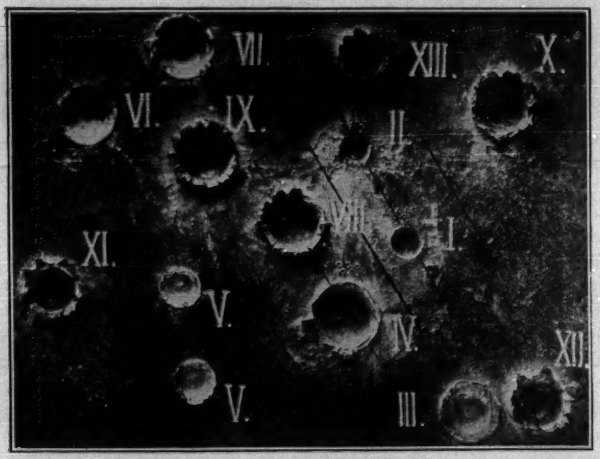


Plate No. 1.

to-day in target-shooting, where time is plentiful. While the results obtained in this manner were very satisfactory as far as accuracy was concerned, they were of course useless for military or hunting purposes. It has taken a comparatively long time to ascertain the exact size of a bullet and the relative difference between the diameter of a bullet and the caliber of the rifle, for which it was intended. The density of the lead employed would alter the size, and as soon as this was apparent, the casting of bullets in a mould was abandoned and the bullets were made

out of lead wire of equal density drawn to size and stamped or pressed. As these bullets were without air-holes from casting, their center of equilibrium came to be as nearly in the same place as mechanical ability could make it. Breech-loading rifles commenced to shoot with surprising accuracy.

One element, of which I have not yet spoken, is the natural drift of the bullet, not the drift produced by the action of the wind. With the twist of the rifling the bullet would drift in the same direction. This was, however, not the only influence. The modus of fastening the sights, the fastening of the receiver and other like things would make the bullet drift. How intense these influences would act is illustrated by the following episode: When the German Government, after the victorious war of '70-'71, wanted to equip its army with the new Mauser rifle, known as Model 6, 1871, it pressed the gunmakers of the world, except the French, into its service. Birmingham, in England, held large contracts. And while all the parts, as well as the finished rifle, were inspected and proved in Birmingham by German officials, the finished arms were sent to the Government factory, Spandau, for their final shooting test. I happened to be a pupil at the Government shooting school, when it was discovered that out of a shipment of 1000 rifles from Birmingham over ninety per cent. would shoot to the extreme right. Here was a puzzler, for all of the proof stamps were on the rifles, the barrels were straight, the caliber exact, etc. Finally it was decided to test the material in the barrel. When the rifle was brought into the factory to have the receiver unscrewed from the barrel, it was found that they were screwed on exceedingly tight and had strained the metal in the barrel. This caused the drifting, and as soon as this strain was removed the shooting quality of these rifles proved to be normal. There are numerous little mechanical defects which cause the bullets to drift, such as rust spots, unevenness of muzzle, etc.

So far all the projectiles were made out of lead. But the usefulness of lead was limited by the fact that the moment you wanted to increase the muzzle velocity over a given point by increasing the powder charge, the developed force was too great for the softness of the material and the bullet would strip; that means it would not follow the rifling, but be driven straight through the barrel. This led to the moulding of the bullet with copper and

lead, the foundation of the present projectile Still the trajectory showed high elevations.

This was changed, however, with the introduction of smokeless powder by Noble. Here was given an explosive force of hitherto unknown power, which, when reduced to safe standards, bade fair to fulfil the dreams of the gun experts as far as flatness of trajectory is concerned. While at first the construction of suitably strong rifles offered some obstacles, these were soon overcome by the combined efforts of the theoretical and the practical men. Nickle was substituted for copper, steel for lead as a core. The riflings were changed in all kinds of ways, until finally there was

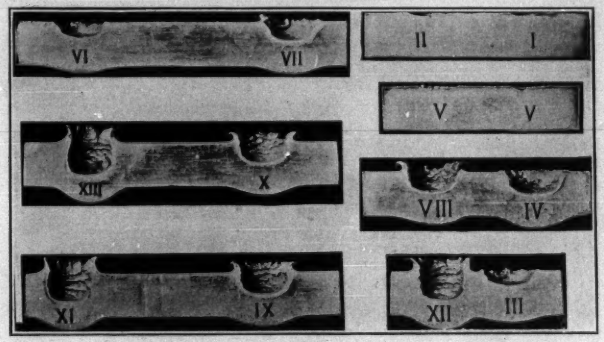


Plate No. 2.

produced the ideal bullet, the sharp-pointed bullet, the Spitzer, which, owing to the fact that it offered the least resistance to the air, and through its perfect balance gives results in accuracy which are very gratifying to the ordnance officers of the army, as well as to the hunter and the marksman.

So marked is the difference between a round-nosed bullet and a Spitzer that the muzzle velocity produced by the same charge in our present Government rifles is 2000 feet in the first second by the round-nosed and 2800 feet by the Spitzer with a gas pressure of 42,000 pounds per cubic inch.

HARTMANN'S PAPER.

The accompanying table gives the number of cartridge, the caliber in inches, the weight of the powder charge in grains, the composition and weight of the bullets and the muzzle velocity of the bullets in feet per second.

Plate No. 1 gives the size of the orifices made in a wrought-iron plate by each bullet fired at the same distance; the orifices are all numbered to correspond with the number of the cartridge in the table. Plate No. 2 shows the depth of penetration in the same iron plate; each orifice in this plate is also numbered to correspond with the number of the cartridge in the table. For instance, cartridge No. 3, calibre .365, loaded with 56 grains smokeless leaf powder, full steel jacket, bullet weight 225 grains, with a muzzle velocity of 2,355 feet per second, made orifice No. 3 in plate No. 1, and penetrated to the depth of orifice No. 3 in plate No. 2.

DR. W. O. GRIGGS.

Cart'ge No.	Caliber Inches.	Powder Charge.	Bullet composition and weight.	Muzzle velocity.
		Black Powder.		
1	.365	54 grs	Soft lead....211.2 grs	1471 ft. per sec.
2	.365	54 grs	Hard lead....206.1 grs	1500 " "
		Smokeless Leaf Powder.		
3	.365	56 grs	Full Jacket..225 grs	2355 " "
4	.365	60 grs	" " 225 grs	2446 " "
5	.315	40.5 grs	" " 220.5 grs	2003 " "
6	.315	43.5 grs	" " 187.5 grs	2380 " "
7	.315	45 grs	Part " 150 grs	2573 " "
8	.315	45 grs	Full " 144 grs	2676 " "
9	.315	46.5 grs	" " 144 grs	2738 " "
10	.315	48 grs	" " 144 grs	2733 " "
11	.315	45 grs	Spitzer.....394 grs	2676 " "
12	.315	46.5 grs	" .....394 grs	2774 " "
13	.315	48 grs	" .....394 grs	2791 " "

PRODUCTION OF CRYSTALLINE QUARTZ AND FELDSPAR IN 1906.

In an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," Douglas B. Sterrett, geologist, of the United States Geological Survey, reports that the production of crystalline quartz and feldspar in the United States in 1906 amounted to 20,082 short tons, valued at $121,671, as against 19,039 tons, valued at $88,118, in 1905, an increase of 5043 tons in quantity and of $33,553 in value. In quantity the production was exceeded only by that of 1903, which was 31,940 tons, while the value was greater than for any previous year. There was a large increase in the output of abrasive feldspar, which forms an important part of the total production. The crystalline quartz output was reported by three producers in Connecticut, one in Pennsylvania, and one in Wisconsin. Mr. Sterrett's paper contains a table showing the production of this abrasive since 1895.

(Stated meeting held Wednesday, June 17, 1908.)

Latest Developments in the Burroughs' System of Book-keeping and Accounting.

Development of the Accounting Machine.

By R. L. Burd.

On behalf of the Burroughs Adding Machine Company, I desire to thank the Institute for the privilege of addressing you this evening on the subject of the Adding and Listing Machine as we know it to-day.

The idea of a commercial machine to add and list figures was original with William Seward Burroughs. The idea occurred to Mr. Burroughs when he was a bank clerk in Auburn, New York, and on account of poor health was ordered by his physicians to give up close, confining work. Believing that it was largely this work which had ruined his health, Mr. Burroughs set about devising a machine which would do the routine work of the clerk; and the rest of his life was devoted solely to this object.

In 1882 he went to St. Louis and began to put his ideas into definite shape, a task which occupied him constantly until he finally developed a practical model in 1889.

Like many inventors, Burroughs did not have money to carry on his experiments, and at an early stage in the development of the machine was obliged to hunt for capital. In this he was met by constant disappointment, as many people looked with suspicion upon a man who was so foolish as to think that he could make a machine do the work of the human brain, and as a result he was often considered somewhat out of his mind.

The very first models which Burroughs made are not in existence at the present time. The first one of which we have any definite record was very crude and had to be abandoned after tests had proven that it was not capable of doing the work required. It

is notable, however, that even in his early models, Mr. Burroughs included many of the essential features of the machine as it is built to-day, and it is a wonderful comment on his ability that after twenty-five years of practical tests it has been found that the original principles, as laid down by Burroughs, cannot be improved upon—and, in fact, have never even been approached by those who have spent years in the study of this subject since the time of Burroughs.

Mr. Burroughs' first aim was to produce a machine that would record figures on paper and would give a correct total of the amounts that were printed, without depending in any way upon human agency, except for the operation of the keyboard. The greatest trouble which he experienced was in getting his printing mechanism to work in exact unison with the totalling mechanism, and eventually he solved this problem by making the two mechanisms integral. This is the famous Burroughs Pivotal Principle. The entire mechanism for printing and adding amounts is mounted on one bar—a bar for each column of figures. The sector teeth, which perform the addition, are placed at one end of the bar, and the type, which perform the printing, at the other end. These bars swing on a central shaft or pivot, and the operation of the machine, therefore, is performed by a simple rocking or "see-saw" motion of these bars.

Other features which Burroughs devised to accomplish the work he had in mind are Locked Keyboard, which prevents the operator from depressing more than one key in any one column without first pressing a correction key; the locked adding mechanism, which keeps the total wheels positively locked at all times, insuring that only those amounts which are depressed in the keyboard shall be printed and added; the hammer printing mechanism, by which the type are fired against the paper, one at a time, doing away with vibration and jar. One essential principle which Burroughs at first overlooked, was the device to control the operation of the machine and guard it against rough treatment on the part of the operator. The necessity for this device was not discovered until the first machines were placed upon the market and subjected to the final test of commercial use.

It was in 1889 that the first machine was placed in the hands of the public, and its development at that time represented an expenditure of more than $300,000. Mr. Burroughs considered the

machine perfect in every respect, because, in operating it himself, it responded perfectly and seemed to have no faults. The machines placed upon the market, however, being in the hands of inexperienced operators, soon gave trouble, and Burroughs found it necessary to visit the different users of the machine, when he discovered that there was a great difference between the machine when operated with his own hands and by careless and unskilled operators.

This was perhaps one of the worst disappointments in all the long series of disappointments which Burroughs experienced in his work. He had reached his triumph as the inventor of the first commercial machine to do this work, and here he was confronted by the failure of the machine, due not to any fault of the

Burroughs sector bar, carrying adding teeth at one end and printing types at the other. The operation of the machine is performed by the rocking, or "see-saw" motion of these bars, one for each vertical row of keys. When the adding mechanism descends a certain number of notches, the printing mechanism must rise an equal distance, so that whatever is added must be printed.

machine itself, but to the fact that it was impossible to train all of the people who might be called upon to use it.

He wrestled with this problem for a long time, and his final solution was the Burroughs Controlling Device, which consists of an automatic governor located centrally in the machine, absolutely controlling its functions and safeguarding the mechanism against rough usage of any kind.

The machines that had been sent out for public trial were now recalled, and as they were received, one at a time, at the old Boyer machine shop, where Burroughs built his first machine, Mr. Burroughs took them in hand and stored them away in a small room in the work shop. When all had been returned and replaced by machines containing the controlling device, the inventor quietly

went to this room one day, without telling anyone his intentions, opened a rear window and tossed all the machines, one by one, out into the paved court yard, where they were heaped up in an unrecognizable mass of material. He then went to the shop and called Mr. Boyer out into the back yard, saying, "I have something to show you." Pointing to the pile of scrap iron, which was all that remained of his early work, he said: "There, I have got rid of all my troubles." This instance only shows the love for accuracy which Burroughs had, and which is shown to-day in his machine. So painstaking was he in all his work that even his drawings were made upon metal plates in order to gain absolute accuracy.

After the controlling device had been placed in the machine and its efficiency established beyond a doubt, the success of the company was assured, and 1,000 machines were built and sold between the years 1891 and 1895. Perhaps the best demonstration of the thoroughness of Burroughs' work is shown by the fact that some of these very first machines are still in use to-day and are perfectly accurate in every way.

The constant increase in the demand for the Burroughs machine is shown by the fact that while it took four years to sell the first 1,000 machines, the sales for the year 1907 alone were 13,314 machines, and there are over 65,000 in use at the present day.

In 1904 the first factory, which was built in St. Louis, for the manufacture of the machine was outgrown, and the American Arithmometer Company, as it was known at that time, moved to Detroit, where a new factory was built providing sixty per cent. more floor space than the former one. The name of the company was also changed at this time to the "Burroughs Adding Machine Company." In addition to moving the machinery and equipment, the company moved its skilled employes, their families and furniture, from St. Louis to Detroit. This factory in Detroit is located on a beautiful, broad, shaded boulevard, and is a model for cleanliness, light, modern appointments and completeness. At the present time the company are planning a building for office use alone which will give them a continuous frontage on the boulevard of two city blocks, with a total floor space in factory and offices of over five acres.

In order to meet the constantly enlarging demands of business,

it is necessary to maintain an Inventions Department, comprising over 100 skilled men—inventors, designers, draughtsmen, and experimental mechanics—who are working constantly bringing out new ideas and enlarging the scope of the machine. It seems remarkable, when we stop to think, that this corps of inventors, including the best minds in the adding machine art, that the fundamental principles contained in Mr. Burroughs' experimental machines, still command the admiration of the best mechanical engineers of to-day.

The pivotal principle is, of course, responsible for much of the success and prestige of the Burroughs machine. This is readily understood, as the friction in the pivotal bearings is very slight, whereas the sliding, dragging, metal-to-metal bearing surface used in most tpyes of machines involves a constant sliding back and forth, which, of course, discharges oil from the bearings in a short time. It is said by those who were acquainted with Mr. Burroughs when he began his work, that he tried a sliding principle at the start, but could not secure accuracy, and found that his results could only be accomplished by using the pivotal principle.

The type bar, or sector, on the Burroughs machine carries the type figures from "naught" to "nine" on its rear end, and the adding rack on its forward end. The machine is constructed so that this bar moves at a high rate of speed with little friction, and to make this possible its weight is supported by the bearing on the center shaft, the bar being perfectly balanced. This not only secures ease of operation, but allows a movement of two or three inches at the ends, with a bearing movement of but 3/32 of an inch, in handling the largest amounts.

The entire machine is constructed on this pivotal principle, and every moving part works on a pivotal bearing and swings in the arc of a circle.

Regarding the controlling device which I have mentioned: In addition to the oil actuated controller, we have two heavy springs which take up all vibration and jar imparted to the machine by means of the handle. In other words, the power applied to the handle is transmitted to the machine through these springs and the controlling device, so that no matter how hard or fast the handle may be pulled, the machine cannot go above the normal speed, and the sequence in which its functions are performed cannot be

disturbed or altered in any way. It will be seen that such perfect control is necessary in a machine which does the work of the Burroughs, for while a watch may vary two or three seconds in the course of a day without disturbing its owner, the Burroughs must not vary a single unit in its tireless daily grind of figures. Therefore, whether the machine is operated fast or slow, by an operator who pulls the handle evenly, or one who jerks it violently, the machine is bound to give the same results in each instance. Therefore, the life of the machine is not determined, or in any way shortened, by the manner of its operation.

Next, Mr. Burroughs realized that it was necessary to securely lock the adding wheels in the front of the machine at all times, and the safeguards thrown around this adding mechanism are perfect. As the handle is pulled forward preparatory to adding an amount, these adding wheels must move out to permit the adding sector to descend, and as the wheels move out they are locked between two teeth in front before they are unlocked in the rear from the teeth in this adding rack. By this you can see that no shock or jar could ever be great enough to disturb the figures on these wheels, which show the correct total at all times.

Next, Mr. Burroughs realized that vibration must be avoided if the machine was to perform its work perfectly and for a long time. Therefore, he did away with vibration in all parts of the machine. In addition to the shock absorbers which I have previously described, he carried out the same idea in the printing mechanism by causing the hammers which perform the printing to strike one at a time, instead of all at once. In the standard sized Burroughs machine there are nine of these hammers, and they fire one at a time, the effect being as though we were to fire a double-barreled shot-gun one barrel at a time instead of both together.

Another thing which Mr. Burroughs provided for was an absolutely interchangeable construction throughout the Burroughs machine. A part which becomes slightly worn after years of use can be replaced with a new one without hand work or special fitting, and this is possible, because Mr. Burroughs constructed the machine in such a way that every part is easily accessible and interchangeable. To maintain this interchangeability it is necessary to have very fine and accurate instruments, and thus the tool room at the Burroughs model factory is one of the best equipped in the

country and employs nearly 200 skilled mechanics, who are very busy turning out the various tools used in the manufacture of the machine.

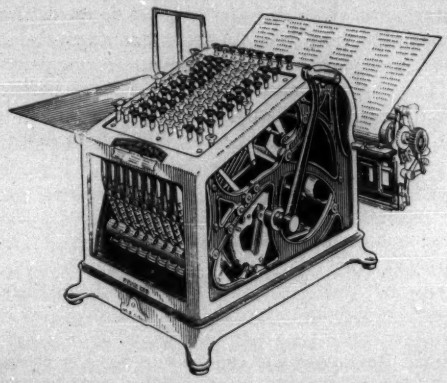
The Burroughs machine is sometimes criticised on the ground that it contains so many parts, but the wonderful length of life of the machines in constant use proves conclusively that there are only enough parts to make a perfect machine for a long length of time. In this connection we might compare two watches, one made to sell for a dollar, the other a good Swiss or American made watch. In the good watch we have more parts, more springs, but we have accuracy and long life. In the other we have fewer parts, also a constant doubt as to the accuracy of the watch, and very short life. In the dollar-watch the number of parts has been reduced to bring the manufacturing cost within the required limit. This makes it necessary for each part to perform the work that should be borne by two or three, and in doing this that part is subjected to great wear, which soon destroys its accuracy.

Mechanical Accounting.

By Thomas M. Jones.

When Mr. Burroughs was endeavoring to raise enough money to perfect his invention, the greatest inducement he had to offer to his prospective backers was that some day they might be able to sell as many as 8,000 machines to the banks in this country. At the present time there are over 65,000 Burroughs machines in use, and hardly one-third of these are used by banks. The first machines that were sold were fitted with a paper carriage to accommodate a roll of paper only. This, at that time, being the only style of paper desired by banks, whose use for the machine was simply making their balances. The first need for a paper carriage to accommodate wide sheets was made apparent by the needs of cotton dealers, who found that they could save a great deal of time by invoicing their cotton weights on the adding machine. Cotton weight sheets were so ruled as to accommodate the weights of one hundred bales. The wide paper carriage was

then devised for this work, and its uses are at the present time almost unlimited. The idea is almost general in the minds of those not conversant with the many uses of the adding machine, that its field is limited almost exclusively to the requirements of the banker. The fact, however, that hardly one-third of the machines in use at the present time are in banks conclusively disproves this idea. Adding machines are now in use extensively by the manufacturer, jobber, retailer, railroad and insurance, and gas and electric companies, and the cotton, oil and coal businesses, dairies, private residences, municipalities, and the United States



Regular model Burroughs adding and listing machine, capacity 999,999,999, equipped with typewriter carriage for tabular work on broad sheets, ledger leaves, etc., up to 18 inches wide. Burroughs are built in fifty-eight different styles, for hand or electric operation, with capacities up to 999,999,999,999,996

Government, and are conspicuous by their absence in any up-to-date business establishment.

The adding machine's work in the bank compares very closely to its work in mercantile concerns. The banker is really a merchant who deals in money for which he pays a certain rate of interest, and sells at a profit of from three to ten per cent. A check represents an order for money just the same as a salesman's order is a requisition for merchandise. In banking establishments adding machines are used for balancing the teller's cash, making out remittance letters, clearing house exchanges, proving the postings made by the bookkeeper

and balancing daily his work, multiplying interest and discount, daily, monthly and yearly statements and in various other ways.

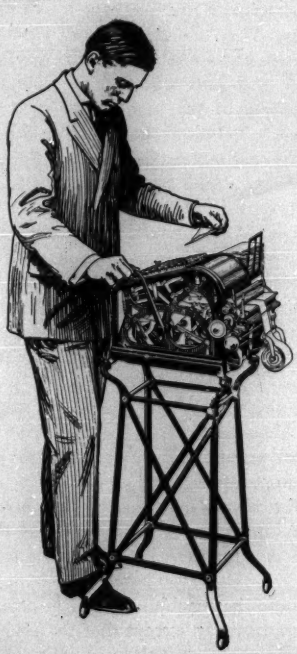
In the manufacturing concerns, the adding machine is invaluable. It enables the bookkeeper to prove daily the correctness of every entry made in his books by what is known as the "Proof of Posting System." He can then prove the addition of his ledger by the use of the statement machine which will make out monthly statements, putting down the charges and credits and extending the balance by means of subtraction. This machine is also equipped, when desired, with letters so that the operator is able to put down an abbreviation of the month and such words as Debit, Credit, Balance, etc. When all the entries in the ledger have been proven, the addition and extension checked, the trial balance then is really a mere form. The trial balance of to-day is merely a proof, made monthly, of the bookkeeper's work, and is not used for statistical purposes, as the data it gives is sufficient for such, therefore if the work is proven and balanced daily, the trial balance is then rendered very simple. The time for making up monthly statements and taking off the trial balance falls right at the end of the month and without the assistance of the adding machine the bookkeeper is badly snowed under in his work for a period of time.

The machine is also used for recapitulating sales, both by salesmen and by the department, used on pay-roll work and very extensively in cost accounting, rendering this particular work, which is of vast importance, very simple. By a system used in connection with the adding machine the cash book can be practically done away with, so far as the entering of the daily receipts is concerned, and the purchase ledger can be entirely dispensed with.

In a jobbing house the machine is used in practically the same way as by the manufacturer, except that the jobber has a greater amount of work in the recapitulation of sales, as is also the case in retail concerns and department stores, and in the latter all of the numerous sales made are audited very quickly on the adding machine.

In the railroad and insurance fields, the use of the adding machine is so extensive that the Burroughs Company has established departments of railroads and insurance. The work of these departments being devising systems for applying the machine to the

various uses of these concerns. Special machines are constructed for this work that will add and list, or list and not add, from one to four columns of figures at a time, and as practically all of the accounting done by these companies is of a statistical nature, the adding machine will eventually be so applied that it will handle nearly all of this work.



L. E. Spalding, of St. Louis, champion adding machine operator. Mr. Spalding holds the world's record of 500 miscellaneous bank checks correctly listed and added on the Burroughs in 6 minutes, 18 seconds.

In the leaf tobacco business, which has not been mentioned, invoices are used on which is shown the number of the case, the gross weight and tare of same and actual weight of contents. These four columns can be listed at one operation on a machine especially constructed for this work, and when the total is taken the gross tare and actual weights are all added at one operation.

When this invoice is made in duplicate by the use of a carbon sheet, the duplicates can be retained in loose-leaf binders as a sales book. This particular use is also applicable in oil, cotton and coal businesses, special Burroughs machines being so constructed as to fit their particular requirements.

In gas and electric light companies, the entire ledger can be made out on the adding machine, for most of these concerns handle their accounts by numbers instead of names, so the ledger sheet may be inserted in the machine and filled out complete. In the gas company's business the account number, the number of cubic feet for both lighting and fuel gas and the earnings are listed. Receipts are also handled by these companies on the adding machine, putting down the account number, the amount of discount and amount of cash received. With the electric lighting companies the use is just the same, instead, however, of listing feet, they list kilo-watt hours.

The United States Government, at the present time uses in the vicinity of five hundred machines, these being distributed in practically every department of the service.

Quite a number of adding machines have been sold to private individuals to be used in their residences for handling the accounting necessary therein, and to contractors and constructors, who use the machine for figuring estimates on jobs and then handling the cost accounting of their contracts.

The foregoing applications of the adding machine give some idea of the vast number of uses to which it has been applied. The possibilities and applications of the machine seem unlimited and the business is practically in its infancy.

The Burroughs Adding Machine Company is at present manufacturing fifty-eight different styles of adding and listing machines, and in order to better care for its ever increasing business has established offices in every city of importance in the United States, and now has representatives in practically every country on earth.

In the course of this lecture a number of slides were used, showing the various parts of the Burroughs machine and the course of the machine in its progress through the Burroughs factory.

One of the views showed the Small Parts Inspection Department, where every part entering into the construction of the ma-

chine is tested by some special instrument devised to absolutely determine the acuracy of the part.

Another showed the Assembling Department, where all these parts are brought for building up into the various sections of the machine. Then there was the Erecting Department, showing the various sections being built into a complete machine.

Following this comes the Inspection Departments, where the machines go after leaving the hands of the erectors. The inspection of the machine is very thorough. The first inspector is not limited to the amount of time he puts into the inspection of any machine. It does not leave his hands until he is satisfied, and then it passes to one of the men who are known as "Second Inspectors," who carefully examine every part of the machine for perfect workmanship, material and erection. The machine then goes to the final inspectors, who are responsible for the perfection of the machine. They test the machine in every conceivable way, and take off record slips showing the work. The machine then goes to the shipping room.

Another view showed the Special Machine Department, where all Burroughs machines having special features are assembled and tested by special inspectors.

There were a number of views of the office departments, including the Accounting Department, General Offices, Stenographic Department, Business Systems Department, etc. The latter is a most important department of the Burroughs work, and is devoted to investigating the uses for the machine in all lines of business and developing ways in which the usefulness of the machine may be enlarged.

PRECIOUS METALS IN WASHINGTON.

The mines of Washington reported to the statisticians of the United States Geological Survey an output of only $221,648 in gold in 1906, a decrease of $183,430 as compared with the production of 1905. The Republic district, in Terry County; the Pierre Lake district, in Stevens County, and the Mount Baker district, in Whitman County, divide the production. Silicious ores predominate, the placer output being about $20,000.

The silver production of the State in 1906 was insignificant, amounting to only 45,878 ounces.

Statistics of the production of the precious metals in the United States in 1906, prepared by Waldemar Lindgren, geologist, are published by the United States Geological Survey in an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," which is now ready for distribution.

In Memoriam.

WILLIAM DANA EWART.

The death at Rome, Italy, on Sunday, May 3rd, of WILLIAM DANA EWART, will be noted with more than ordinary regret by those whom his genial disposition had made his friends and by the many others to whom his most prominent invention has made his name familiar. Mr. Ewart was born in Ohio about fifty-six

years ago and at a comparative early age gave evidence of an inventive mind and rare mechanical ability. He was the inventor of the malleable-iron detachable drive chain, first known under his name, and in later years as link-belt, which has formed an important part of agriculture and other duplicate machinery, and has, to possibly a greater extent than any other single invention, helped the wonderful progress in the development of elevating and conveying machinery during the past thirty years. This

drive chain has been continuously manufactured by the Ewart Manufacturing Company and exploited by the Link-Belt Machinery and Link-Belt Engineering Companies, till in 1906 all three Companies were consolidated into the Link-Belt Company, a corporation in which he was largely interested and whose fortunes are still largely directed by his former associates. Mr. Ewart, whose abilities brought their proper reward, was not only an inventor, but a man of executive capacity, possessing a rare gift for harmonizing differences and securing cöoperation. His health becoming impaired, he retired in his early prime from the activities of business and sought renewal of physical strength under more favorable climatic conditions abroad. O. N.

PUMICE IN THE UNITED STATES.

The production of pumice in the United States in 1906 amounted to 12,200 tons, valued at $16,750, as against 1832 tons, valued at $5,540, in 1905, an increase of 10,368 tons in quantity and of $11,210 in value. This large increase came from Nebraska, from deposits near Orleans, Harlan County, and Ingham, Lincoln County, which are being extensively worked. This Nebraska pumice is chiefly a volcanic ash or powdered pumice, and is used in the manufacture of scouring and cleaning preparations.

Although deposits of pumice are found at several localities in the United States, only those most favorably located as regards mining and transportation facilities can be worked in competition with foreign deposits furnishing the imported material, the greater part of which comes from the island of Lapari. The value of the imports of pumice in 1906 was $111,695, as against $77,489 in 1905, an increase of $34,206.

Pumice stone is found on the beach along the east coast of New South Wales and Queensland, probably having been washed across the ocean from volcanic islands. Such pumice must be of good quality, as only the lightest would make such a trip, but it would be necessary to free it from sand which it may have picked up along the beaches before it would be of value for painters' work.

The production of pumice and other abrasives in the United States in 1906 is reported by Douglas B. Sterrett, geologist, of the United States Geological Survey, in an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," which is now ready for distribution by the Survey.

THE value and tonnage of British exports of iron and steel in the first six months of 1907 exceeded all records. The total pig iron exports were 1,061,275 tons, which compare with 706,466 tons in 1906 and 449,760 tons in 1905 (six months only), and of these quantities the United States took 329,552 tons in 1907, against 114,374 tons in 1906, and 81,445 tons in 1905.

Section of Photography and Microscopy.

(Stated meeting held Thursday, March 12, 1908.)

Photographing Water in Motion.

By J. W. Ridpath.

Among the many charming bits of landscape scenery found almost everywhere over the country perhaps no single class has greater charms for the eye of the photographer, or gives him more pleasure, than does the ever popular brook. Its charms have been sung by the poet and its beauty painted by the artist; it is therefore not surprising that the budding photographer should try to catch and perpetuate its beauties.

Doubtless most persons will agree that the beauty of the brook consists largely in its winding, verdure-fringed border and its clear rippling water. If the vegetation be dry and lifeless, as in spring and autumn, the brook still retains its chief charm, the sparkling water. If by the construction of a temporary dam, or other cause, the water be cut off, the scene at once loses its attractiveness. Who admires a dry brook? Rob the ravine of its water and you rob it of its chief beauty.

Many beginners in photography imagine that because the movement of water is rapid, it would be useless to attempt a picture of the sparkling ripples, wavelets, or little water-falls, so frequently found in brooks, with anything short of a rapid lens and quick-moving shutter; and they frequently complain that they are unable to take good pictures of landscapes containing water, because the lens or shutter on their camera is not sufficiently rapid to photograph water in motion.

It is to correct this mistaken notion, and encourage the beginner to try what he can do with his camera, that this short article is written. As a matter of fact, thousands of excellent land-

scape pictures are taken with the ordinary rapid rectilinear lens and low-priced shutter, even when there is considerable wind agitating the leaves and swaying the branches of trees and rippling the surface of the water. An old-time professional photographer told the writer, that even with wet plates and their slow disposition, he had taken many landscapes for the trade, especially along streams, showing bridges, and was thought to be quite successful in photographing moving water, although the time required was

Turk bridge, near Doylestown, Pa. Exposure 1 second. Negative by the author.

what we would now call excessively long. A collection of marine views, which show the ocean in its different moods, from a rippled surface to waves breaking over the deck, were all taken by an officer of a large ocean steamship, with a Waterbury lens and a sliding shutter that was anything but rapid; and these pictures, wherever shown, were always admired.

The reasons why a liberal exposure frequently yields natural-looking water pictures, may be better understood if we remember that the average eye is incapable of forming a distinct impression of an object instantaneously. It requires a fraction of a second

to do so. By careful training the eye's speed may be somewhat increased. Robert Houdon claimed to have trained his eye to a point of time and accuracy of observation much beyond its natural capabilities. It is said that a positive image, strong and sharply marked, may be made on the retina, by a good light, in one-third of a second; and yet this does not hold true in all cases, because eyes differ. One may require nearly half a second, while another may have a clear perception in much less time, possibly one-tenth of a second. Again, an impression once made, may last on the retina as much as one-thirtieth of a second. Therefore it appears that the position of the moving object, as seen by the eye, is not its real position at that point of time, but rather the position it occupied a fraction of a second before. Again, the field of distinct vision is extremely limited; at the same moment we see clearly only a very small portion of the visual field; in reading a book the eye moves along the lines, clearly and sharply seeing only a small portion at once. By careful training this faculty may be greatly increased. Houdon, the noted French magician, by persistent practice, became able to walk past a show window, occupying perhaps two seconds of time, and then name to his son the many articles displayed in the window.

The rapid lens and quick-moving shutter have revolutionized our ideas of the movements of birds flying and animals running, and corrected many long-standing errors; but a rapid lens is not necessarily a universal lens.

In photographing a rapidly moving object, we may wish to portray what actually took place, although it may differ materially from what the eye saw; in fact the movement may have been too rapid for the eye to see it. The movement of water is very different from the movement of birds, animals, or other objects of definite shape. In photographing a rapidly-moving bullet, falling shot, a trotting horse or flying bird, we expect to show the definite shape of the moving object, rather than the movement of the object; that is, we show a bird with outstretched wings, apparently suspended in mid-air, rather than the moving of either the bird or its wings in the air. In the case of water, the individual particles are not visible, as in falling shot, therefore we show the shape of the general mass or small aggregations of the mass, and by their shape or position obtain the idea of motion. While a very short exposure may, and will, give the wave formation, sharply

defining every ripple upon the surface of the water, the resulting photograph will lack the softness of the scene as observed by the eye; and except in the matter of outline or shape, will probably lack the semblance of movement, which gave to the scene its principal charm, and to preserve which, the plate was exposed. It is true that an exposure of 1/1000 of a second would show the water of a cascade, but the resulting picture would probably resemble suspended motion more nearly than moving water.

Experience appears to show that the slight blurring caused by a

Little dam at Ogontz, Pa. Exposure 1-25 second. Negative by the author.

slow shutter, instead of detracting from the appearance of movement in water, rather enhances the idea of motion.

In photographing a landscape, with or without water in the view, we usually wish to depict the scene as we saw it, preserving that charm which appealed to us at the time; therefore the desired picture should be a representation of what the eye actually saw, rather than the details of a movement too rapid for the eye to perceive or form a clear conception of. In the opinion of the writer this effect can readily be obtained at a moderate speed, say

1/10th to 1/25th of a second, under ordinary conditions, with a good rapid rectilinear lens. We should also recognize the fact that the lens, unlike the eye, sees the whole visual field at once, and the exposure should be sufficient to show the trees and other surrounding vegetation as well as the flowing water, otherwise the short exposure for water, would give underexposure for the trees and grass.

While the writer would recommend the purchase of as good a lens as your purse can readily afford, he would advise the amateur that extreme rapidity is rarely needed in landscape work; and a good lens with shutter set at moderate speed will usually yield satisfactory work.

The paper was illustrated by thirty-one photographic slides, as follows:

1/100"—Dam in Bethlehem.
1/75 "—Cruiser Brooklyn.
1/75 "—Battleship Texas.
1/60 "—Sunset.
1/50 "—Cruiser Fulton.
1/50 "—Breakers.
1/40 "—Iron bridge—Bethlehem.
1/40 "—Lighter and Tug.
1/25 "—Ogontz Dam.
1/25 "—Stone Bridge.
1/25 "—Schooner.
1/25 "—Bathers.
1/25 "—Rustic Bridge.
1/25 "—Breakers.
1/25 "—Little Dam at Ogontz.
1/25 "—Tacony Creek.
1/25 "—Willows.
1/25 "—Foot-bridge.
1/25 "—Wanamaker's Lake.
1/25 "—Sloop.
1/25 "—Tree and Race.
1/25 "—Schooner.
1/25 "—Wave.
1/15 "—Darby Creek.
1/10 "—Dam at Rocks.
1/10 "—Quarantine Boat.
1/5 "—Upper Falls—Childs' Park
1/2 "—Bushkill Falls.
1/2 "—Liberty Falls.
1 "—Turk Bridge.
90 "—Valley Green Bridge.

ANNUAL REPORT OF THE DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY.

The twenty-eighth annual report of the United States Geological Survey, covering the fiscal year ended June 30, 1907, just published, records some notable events in the history of that organization. The retirement of Director Walcott to assume the secretaryship of the Smithsonian Institution was distinctly the most important of these events. The new Director, George Otis Smith, in this, his first report, briefly outlines the changes made under his predecessor. Among these changes he mentions the raising of the standard of the topographic maps, with the representation thereon of land subdivision lines, and the extension of exact leveling and primary triangulation; the placing of the entire topographic and geologic force within the classified serivce; the obtaining of authority from Congress to issue in advance of the printed volume the separate chapters of the annual report on mineral resources of the United States; the enlargement of the Survey's work in hydrography, mineral resources, and geology; and the provision for reconnaissance surveys of regions of economic importance.

The growth of the Survey during the thirteen years of Mr. Walcott's administration is shown by the increase in the extent and the scope of its operations. The appropriations for the last fiscal year amounted to more than four times the total of those made thirteen years ago, and there was, of course, a corresponding increase in the amount of field and office work performed. The development of the relations between the Geological Survey and the public within the same period is measured by a more than fourfold increase in amount of official correspondence, a nearly fourfold increase in number of printed pages in the various reports of the year, and a more than fivefold increase in copies of maps printed, while the total annual distribution of publications—books and maps—grew from less than 200,000 to nearly a million copies, the sales increasing from $2,100 to more than $18,000. The extent to which the results of the Survey's work are now utilized by the industrial world and by educational and scientific institutions furnishes the best indication of the success achieved.

The completion of the separation between the Reclamation Service and the Geological Survey and the organization, within the Survey, of a technologic branch, for testing fuels and structural materials, were also important events of the year.

The report gives detailed accounts of the year's work in topography, geology, hydrography, technology, and chemistry, and in the collection of statistics of mineral resources and mineral production of the United States. Especial note is made of surveys of coal lands, of surveys in Alaska, of work relating to water resources, and of cöoperation between the States and the National Survey.

The Survey has suffered considerable embarrassment by its success as a training school for mining geologists, having lost seven geologists during the year through their employment by mining companies at larger salaries.

The publications of the year consisted of 177 new documents, 109 new maps, and 255 reprints of maps.

(Stated meeting held Thursday, May 14, 1908.)

An Improved Microscope.

By Frank Teal.

While the optical elements of the modern high power microscope have obtained a wonderful degree of perfection, and the workmanship on the entire instrument is worthy of admiration, an observing microscopist cannot fail to note certain mechanical deficiencies affecting the manipulation in high power work.

The instrument under consideration is the product of evolution (*not* Darwinian), in which—starting from a very crude and elementary nucleus—the various features to which attention is called, were suggested, *by their need*, and added, piecemeal.

To an amateur, who is not restricted in originality of thought by consideration of conventional forms and methods—possibly through his ignorance of them—a much bolder treatment of the subject may be attempted, without the exercise of any great amount of courage.

The several improvements to which attention is called may be divided into three groups: First, focusing; second, manipulation of the slide; third, illumination.

One feature, not included in this classification, may be briefly referred to, as—though exceedingly simple in itself—it is very important in its effect. Few manipulators have escaped the harrowing experience, in focusing high power work, of bringing the objective in contact with the slide; with the result of destruction of the slide, and, possibly, injury to the costly objective! The great power of the micrometer screw, due to its fine thread, renders it impossible to detect the slight increase of resistance due to a pressure sufficient to destroy the fragile slide, while the extreme difficulty of avoiding passing the focal plane—where the working

distance is short, as it is, necessarily, in immersion work—renders it difficult, even with the greatest care, to avoid such accidents. The remedy is exceedingly simple and effective, as shown.

The working barrel, to which the focusing adjustments are attached, is made of a diameter large enough to receive the body tube, which is fitted accurately to the bore of barrel, but sufficiently free to avoid friction. A collar on the tube supports the weight of the latter, and prevents downward movement, while the tube is perfectly free to move upward, with only the resistance due to its weight. In operating, should the lens come in contact with the slide, its motion ceases, and only the barrel moves, which, of course, is harmless.

By obviating the necessity for extreme care, focusing can be done with much greater rapidity, and with absolute safety.

FOCUSING.—For coarse adjustment the rack and pinion leaves nothing to be desired; it is quick, simple, and efficient. In the micrometer adjustment, however, the almost universal use of the milled head on the screw renders the device deficient in the necessary delicacy of adjustment in resolving difficult objects, and it was from the experience of such difficulty that the necessity for improvement was suggested.

Like Columbus' egg, the remedy was very simple. Merely a worm-wheel on the screw, in place of the conventional milled head, and a worm shaft with milled head, at right angle to the screw.

Comparing the delicacy of adjustment of the two methods—the conventional screw is 72 threads per inch, and with milled head graduated to 100 ths., the movement can be made as fine as 72x100=1/7200 of an inch.

With worm-wheel adjustment, the screw 32 th'ds. per inch; worm 32 th'ds. per inch, and milled head on worm divided to 25 ths., we have 32x32x25=1/25,600. Or, with milled head divided to 100 ths., 1/102,400 inch.

Of course the necesary take up adjustments to both screw and worm-shaft are provided, to prevent lost motion.

SLIDE ADJUSTMENT.—The usual spring clips are discarded, as the form of mechanical stage used renders them superfluous. The main stage is of the revolving type, graduated to 360°. It is rotated by a bevel gear and pinion movement, and provided with a locking device to retain it in position when adjusted. The top

plate of stage is provided with a male dovetail slide placed at right angle to the column. This serves as the guide for in and out movement of the mechanical stage; and also forms the working face of the main stage. The transverse movement is by means of a dovetail slide carried by a tempered steel plate 1/100 inch thick, having a central opening of a size to prevent covering the stage aperture at any point of adjustment. An internal dovetail forms the slide carrier. It is made wide enough to contain a flat, bow-shaped spring, which is set at an angle corresponding with the opposed dovetail. The slides are simply slipped into place, and are held by the spring firmly against the bottom plate, and the side of dovetail. Adjustment scales, graduated to 1/100 inch, are provided for both movements. The in and out movement is by spiral rack and pinion; and the transverse movement by quick thread screw. The pinion and screw shafts are carried out to convenient distance beyond the stage, and are provided with milled heads. Being side by side, the manipulation of the slide is exceptionally convenient. Owing to the extreme thinness of the mechanical stage, the sub-stage condenser (Abbe) may be brought into immersion contact with the slide, even with the stage iris is closed to smallest aperture.

ILLUMINATION.—A very simple and efficient device is provided by which the column may be rotated independently of the base. The motion is perfectly smooth and easy, and yet there is sufficient friction to prevent accidental movement. The value of this adjustment can only be realized from experience in its use. Frequently a mere touch will resolve an object after much vexatious effort with all other adjustments.

While the sub-stage—i. e., the Abbe condenser, with its various adjustments and accessories—is of entirely original design, there is no thought of its showing any superiority over existing types.

One of the most important points in connection with illumination seems to have been completely ignored by makers of these instruments, in their failure to provide mechanical means for mirror adjustment. The crude method of tilting and pulling the mirror this way and that, by grasping it with finger and thumb, is but little calculated for movements which, really, require extreme delicacy. The advantages of such adjustment cannot be fully realized without experience of how infinitesimal a movement can

produce the desired effect, which could otherwise be only laboriously obtained.

The mirror bar is capable of swinging to about 45° either side for extreme oblique illumination; and, by means of a parallel rod and binding screw, can be rigidly locked in any adjusted position. The bar is bored throughout its length to receive a post, to which the yoke of mirror frame is attached. The post is held in any desired position by means of a binding screw, and admits of up and down, and radial adjustments of the mirror. The mirror yoke is attached to the post by a trunnion provided with a worm wheel. and is actuated by a worm shaft with milled head. The trunnions of mirror frame are also provided with worm wheel adjustment, at right angle to movement of the yoke. Neither of these devices interferes with manipulating the mirror in the ordinary manner, but the use of them firmly locks it in the adjusted position.

AUTOMATIC IRIS SHUTTER.

The distinctive feature of this shutter is the adaptation of the iris diaphragm principle to the functions performed by other types of shutters, with the object of obtaining a more symmetrical action of light in making exposures.

The action of the iris—whether used as a shutter or a stop—is, necessarily, the same; it effects an equalization of focus in either case, without disturbing the degree of uniformity of illumination due to the quality of the lens.

The form of iris used for a diaphragm or stop, requiring a large amount of applied motion to effect the two extremes of adjustment, is, obviously, inapplicable to the shutter.

In case of the latter, the necessity for extremely rapid movement in opening and closing for instantaneous exposures, limits the amount of applied motion to a relatively short travel, and therefore, requires a construction of the iris, the reverse of that used as a stop. Also, as it is manfestly impossible to completely close this aperture, a supplementary leaf, having an independent movement, is necessary for completing the closure, to render it light proof.

To obtain the required rapidity, and to avoid shock at the change of motion from opening to closing, a continuous applied motion is, practically, a necessity; and, in conjunction with the

other elements of the actuating device, the toggle appears to afford the most desirable form of mechanical movement.

This toggle is centrally connected to the piston rod of a pneumatic cylinder, and is guided, for the entire stroke, in the central position; thus causing equal end motion, outwardly, to the two links. The outer ends of the latter are connected to a pair of rockers, or bell-cranks, which are, in turn, adjustably connected to the operating rings of the iris. As these rings are caused to move in opposite directions, the amount of applied motion required is but one half of what would be necessary if one of them were stationary; and as a resultant of this arrangement, the speed of the shutter is doubled.

As previously stated, a single impulse of the pneumatic piston will effect both the opening and closing motions of the shutter; and by simply arresting the movement at half stroke, at which point the toggle is fully expanded, the shutter will remain open until closed by a second impulse of the piston. By this means there is great latitude possible in making time exposures—say from a quarter second to any interval desired.

It follows, from this arrangement, that, in order to avoid the necessity for setting the shutter after making an exposure, a double acting pneumatic cylinder is required, so as to make the return stroke of piston effective, in the same manner as the outward stroke.

The term "automatic," as applied to this shutter, is descriptive, in that, in operating it, for either instantaneous or time exposures, it is only necessary to press the pneumatic bulb, regardless of the position of the piston or its connections. To effect the reversal of piston movement, a very simple air-impelled valve is supplied to the cylinder, the action of which is to cause admission and exhaust at the two ends, alternately, in the same manner as the slide valve of a steam engine. The valve is unconnected with any of the moving parts—receiving its motion from the action of the air at each pressure of the bulb—and it is impossible to give an impulse to the piston without causing a coincident reversal of the valve. The entire device has proved entirely satisfactory, after having been in use for about six years.

EXPORTS OF FOREST PRODUCTS.

Uncle Sam's exports of forest products have shown higher and higher values during the last five or six years. This has been the case, although reports show that there has not been a corresponding increase in volume. For instance, the quantity of sawed timber exported from this country has increased less than twelve per cent. in the last four years, while the price has increased over fifty per cent. Again, the amount of rosin exported has increased but little, while the price has more than doubled.

From 1903 to 1906 the value of staves showed very little increase, but in the year 1907 there was a decrease in the number exported of about ten per cent. together with an increase in the price of about twenty per cent. This last would seem to indicate a recognition of the fact that the supply of the highest grades of white oak is rapidly diminishing. The staves exported are almost exclusively of the highest grades of white oak, and form about one-fifth of the annual production of white oak staves in the United States. As might be supposed, a large part—eighty per cent—of the staves went to Europe, forty per cent. to France. The export trade makes a heavy drain on the supply of white oak.

Boards, deals, planks, and sawed timber made up fifty per cent. of the total value of forest product exports. Rosin ranks next, with nearly ten per cent. of the total value of these exports. Spirits of turpentine follows with about ten per cent. Four-fifths of the rosin and turpentine go to Europe.

The number of shingles exported has decreased fairly regularly since 1903. In 1907 there were shipped less than half the number that were exported four years before. More than fifty per cent. of these shingles go to Mexico, while less than ten per cent. were shipped to ports outside of North America. This shows how few shingles are in demand abroad. The total exports of shingles represent less than one-fifth of one per cent. of the production of this class of material in the United States.

The amount of wood exported in the form of hewn or sawed timber and lumber was about seven per cent. of the total lumber cut in the United States in 1907. More yellow pine is exported than any other kind of timber. The order is yellow pine, Douglas fir, and redwood. Although there are no figures which bear directly on the amount of yellow pine lumber annually exported, it is estimated that at least thirteen per cent. of the yellow pine cut finds its way to other countries. Probably a third of the Douglas fir exported went to South America.

The redwood exported forms an important item. Australia and the Orient together took forty per cent. of the total and South America thirty-two per cent. The exports of redwood in 1907 were about five times what they were twelve years ago, and were larger than those of any previous year. The shipments to Australia and the Orient especially have been increasing steadily during this period. The shipments to South America of redwood, as well as a number of other forest products, has increased greatly in the past two years.

Section of Physics and Chemistry.

Formation and Preparation of Aluminum Carbide.

By M. Camille Matignon,

Translated from "Annales de Chimie et de Physique," Eighth Series. Vol. XIII, p. 276, February, 1908,

By W. J. Williams, F. I. C.

Aluminum carbine, C_3Al_4, was prepared for the first time by Moissan* by heating aluminum in a charcoal crucible in the electric furnace. This scientist has recorded the principal properties of this combination and has drawn particular attention to its gradual (slow) decomposition by water, with the production of methane.

$$C_3Al_4 + 6H_2O = 3\,CH_4 + 2\,Al_2O_3.$$

Moissan's discovery had been preceded by the investigations carried on by Mallet and Franck, with the object of combining aluminum with carbon.

Mallet† had heated the metal in a charcoal crucible lined with lamp-black, without effecting the slightest combination. The operation was conducted in a Deville furnace, in which a temperature above 1700° can be attained, yet the metal showed no other change than a deposit of carbon adhering to the surface. This compact carbon was the result of the reduction of the carbon monoxide, formed at the expense of the carbon di-oxide gas, passing over the plumbago crucible.

Later Franck,‡ repeating Mallet's experiment, believed he obtained small quantities of aluminum carbide by raising a mixture of powdered aluminum and lamp-black to a very high tempera-

*Comptes Rendus, Vol. CXIX, 1894. p. 16.
†Journal of Chem. Soc., Vol. II, 1876, p. 349.
‡Bull. Soc. Chem., Third Series, Vol. XI, 1894, p. 446.

ture. The product had not changed its appearance, but when treated with dilute hydrochloric acid it disengaged hydrogen mixed with a little acetylene. From the presence of this gas Franck concluded the production of a small quantity of carbide. This conclusion was obviously inexact, since, as Moissan showed later, aluminum carbide does not give off acetylene from contact with water. Besides, it is easy to understand the mechanism of the production of acetylene in another way. Lamp-black always contains small quantities of calcium salts, the phosphate and the sulphate, which are reduced by the excess of aluminum setting free calcium, and this metal combines immediately with carbon to form calcium carbide, which is decomposed by water with the production of acetylene.

In 1901, Berthelot* undertook to determine the heat of formation of aluminum carbide, prepared by Moissan's method. The sample used left an insoluble residue after treatment with hydrochloric acid amounting to 4.74 per cent. Further, it was difficult to attain the total combustion of the carbide in the calorimetric bomb, so that the value obtained could not be considered as determined with great precision. Nevertheless the actual heat of formation is closely approximate to the figure obtained by Berthelot after making corrections; $C_3 + Al_4 = C_3Al_4 + 244.8$ Cal.

Notwithstanding the above reservation, this is incontestably a very high figure. To make a comparison let us compare as well the heat disengaged by 1 atom of aluminum to form the carbide, the iodide and the sulphide; we obtain the following table:

C	61.2 Cal.
I	70.3 "
S	63.2 "

with numbers of the same order of magnitude.

In spite of the unsuccessful attempts of Mallet and Franck, it occurred to me, considering the great heat of formation, that the combination of the two elements could be realized, without the intervention of the high temperature of the electric furnace; at least, although *a priori* it seemed but slightly probable, that the reaction would not exceed the zone of "fritting" except at this very elevated temperature. Experience verified my foresight.

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*Comptes Rendus, Vol. CXXXII, 1901, p. 281.

I. Aluminum carbide can be conveniently prepared by heating an intimate mixture of the two constituents in a Perrot furnace. It is well to use an excess of aluminum, which is easy to separate from the carbide produced. Experiments have been made employing the following proportions: 24 parts of carbon to 70 or 140 parts of metal. The carbon is taken in the form of lamp-black, previously calcined to remove moisture. Its intimate mixture with the powdered aluminum is insured by kneading them with spirits of turpentine. The reaction is finished after heating 20 minutes in a good Perrot furnace.

The roasted product presents the form of a well-fritted mass of a slightly olive yellow color. Under the microscope the carbide presents a crystalline appearance; if an excess of aluminum has been used, it is interspersed with small, brilliant globules. These globules can be easily removed, as Moissan has shown, by a rapid treatment with cold hydrochloric acid, or, perhaps better, by substituting a solution of potassium hydroxide for the hydrochloric acid. The carbide is attacked so slowly that decomposition is prevented.

Before making a communication* recently to the Academie des Sciences, on this subject, which I had studied in 1903, I had examined the products of the preparation and had recognized in some of them the presence of small, brilliant metallic scales, yellow, of a hexagonal shape, of almost uniform dimensions of about 0.20 mm. in diameter. The very transparent, yellow scales had the same appearance as the aluminum carbide crystallized by Moissan; hence I thought I had obtained this body in a well crystallized condition. In fact, however, these crystalline scales did not disengage any gas after being in contact with rain water for two weeks; they preserved the same appearance after two weeks' exposure to the air. It seems very probable that these scales consist of aluminum oxide colored yellow by traces of impurities.

A sample of good appearance containing aluminum was attacked by water without having the excess of aluminum previously removed. A gas was obtained which was submitted to eudiometric analysis:

Total gas	5.6 c.c.
Oxygen added	14.35 "
After the spark	8.95 "

*Comptes Rendus, Vol. CXLV, 1907, p. 676.

After absorption by KOH. 3.65 c.c.
After absorption by pyrogallic acid..... 0.00 "

This composition is deduced:

CH_4.....	96.36 cc.
H.....	3.63

The decomposition of the carbide by water is very slow, and requires several weeks; during this time the aluminum in excess, especially in the presence of aluminum hydroxide, decomposes a little of the water, setting free hydrogen. Practically the gas is almost pure methane.

With a product freed from metal in excess, the gas collected is pure methane, as was proved by volumetric analyses:

Gas analyzed.....	4.0 c.c.
Oxygen added.....	21.3 "
After the spark.....	17.05 "
After absorption by KOH.....	13.05 "
After absorption by pyrogallic acid.	0.03 "
Contraction	8.25 "
CO_2	4.00 "
Oxygen absorbed.....	8.28 "

Theoretically, pure methane would give:

Contraction	8.00 c.c.
CO_2	4.00 "
Oxygen absorbed.....	8.00 "

Not only does aluminum carbide give pure methane, but also yields almost the theoretical quantity of gas.

0.2323 gram of the purified product disengaged successively in contact with water 42.5 cc. of gas collected at 17.5°, then 69.5cc. measured at 23° under atmospheric pressure. The total volume of gas reduced to 0° and 760 mm. was found equal to 103.6 cc. instead of 108.4 cc. according to theory, being a yield of 95.6 per cent.

6.3 cc. obtained from the first portion were analysed:

Gas	5.5 c.c.
Oxygen added.....	17.85 "
After the spark.....	12.45 "
After absorption by KOH.....	7.05 "
After absorption by pyrogallic acid.	0.05 "

Contraction	10.9 c.c.
CO_2	5.4 "
Oxygen absorbed	10.9 "

Pure methane would have given:

CO_2	5.45 c.c.
Contraction	10.90 "
Oxygen absorbed	10.90 "

In another operation 0.2775 gram of carbide gave, after being attacked by water for several months, a total disengagement of 125 cc. instead of the theoretical 129.5 cc., a yield of 96.6 per cent.

II. If iodine and sulphur are intimately mixed with powdered aluminum, they combine rapidly as soon as combination has been artificially provoked at one point of the mixture. It was natural to try if the re-action of carbon on aluminum, which disengages a quantity of heat of the same order of magnitude, would propagate itself if it should be started with a primer as in Goldschmidt's method.

Experience showed that to obtain this result it was necessary to use an excess of aluminum. An intimate mixture of 24 parts of carbon to 140 parts of aluminum re-acted with the formation of the carbide when the priming powder (binoxide of barium and aluminum) was ignited on its surface, the re-action continued to the bottom of the crucible; it was complete. In fact, a part of the aluminum in excess combines with the oxygen or with the nitrogen of the atmosphere and consequently produces a complementary heat which facilitates the synthesis of the carbide.

The re-action sets free pure methane, or methane mixed with hydrogen, according as the product has, or has not, been purified.

Here are the results of an analysis of methane obtained by decomposition of a product prepared without exterior heat:

Gas analyzed	6.0 c.c.
Oxygen added	17.5 "
After the spark	12.1 "
After absorption by KOH	6.45 "
After absorption by pyrogallic acid	0.35 "
Contraction	11.40 "
CO_2	5.65 "
Oxygen absorbed	11.40 "

Methane gives:

Contraction	11.30 c.c.
CO_2	5.65 "
Oxygen absorbed	11.30 "

III. It is evident from the preceding results that carbon and aluminum will react when a mixture of them is heated with the aid of the oxy-acteylene blowpipe. Practically, the roasted product obtained after some minutes heating re-acts slowly with water, giving off almost pure methane.

A single analysis was made and gave the following results:

Gas analyzed	3.8 c.c.
Oxygen added	10.0 "
After the spark	6.3 "
After absorption by KOH	2.7 "
After absorption by pyrogallic acid	0.2 "
Contraction	7.5 "
CO_2	3.6 "

Methane gas should give a contraction of 7.2 with a volume of 3.6 of carbon dioxide gas.

IV. Aluminum carbide can also be prepared by compelling the chlorides of carbon to act on the metal. *A priori* the success of the method does not appear doubtful, if the disengagement of heat corresponding to the re-action is considered. With hexachloro-benzene, for example, the re-action is

$$10\ Al + C_6Cl_6 = 2\ AlCl_3 + 2\ C_3Al_4 + 727.6\ Cal.$$

Besides the volatility of the aluminum chloride permits the separation of the two products of the re-action, and the pure carbide can be obtained.

Powdered aluminum, previously freed from foreign matters which render it impure, is mixed with the theoretical proportions of Julin's chloride, C_6Cl_3, and the whole is heated in a sealed tube at a temperature of 225° C. Under these conditions, the reaction, which is very exothermic, is often very violent, and the sealed tube frequently breaks if there is any notable quantity of matter. To avoid this inconvenience it is necessary to introduce only a small quantity of matter and to spread it all over the length of the tube held in a horizontal position during the heating. In this operation, carried out in a closed vessel, I have used benzene per-

chloride, which is less volatile than the other carbon chlorides, in order to decrease the pressure in the tube.

When the reaction is incomplete the carbon chloride in excess and the aluminum chloride can be easily removed by a current of hydrogen gas. A rapid washing with water carries off the aluminum chloride.

The burned product of an unfinished reaction has decomposed water, forming methane and hydrogen, finely divided aluminum reacting easily on the latter in presence of aluminum chloride, as M. Ditte has shown.*

In an earlier analysis, made before the isolation of the carbide, a gaseous mixture was obtained consisting of 44.7% of methane and 55.3 % of hydrogen;

Gas analyzed	6.02 c.c.
Oxygen added	13.37 "
After the spark	8.95 "
After absorption by KOH	6.25 "
After absorption by pyrogallic acid.	0.0 "
Contraction	10.44 "
CO_2	2.70 "
Oxygen absorbed	7.12 "

The mixture indicated above would have given:

Contraction	10.41 c.c.
CO_2	2.70 "
Oxygen absorbed	7.07 "

The same product rapidly washed with water to remove the aluminium chloride yielded much less hydrogen:

Gas analyzed	5.2 c.c.
Oxygen added	12.6 "
After the spark	7.6 "
After absorption by KOH	2.9 "
After absorption by pyrogallic acid.	0.0 "
Contraction	10.2 "
CO_2	4.7 "
Oxygen absorbed	9.7 "

The gaseous mixture analysed then contained 90.4% methane and 9.6% hydrogen. Theoretically, such a mixture would yield:

*Ditte: Researches on the properties of aluminum and its applications. Paris. 1900.

Contraction	10.15 c.c.
CO_2	4.70 "
Oxygen absorbed	9.65 "

Finally, the same mixture, after removing the metal in excess by a rapid treatment with cold alkaline solutions, gave pure methane.

Gas analyzed	5.14 c.c.
Oxygen added	14.6 "
After the spark	9.50 "
After absorption by KOH	4.46 "
After absorption by pyrogallic acid	0.05 "
Contraction	10.24 "
CO_2	5.04 "
Oxygen absorbed	10.18 "

I have said that the action of the metal on Julin's chloride was difficult to effect, and, at the same time, avoid rupturing the sealed tube. If the initial mixture is heated in a test-tube, the reaction is extremely violent. The mixture can also be placed in a crucible and the combination be induced in one spot by the help of an appropriate primer, ignited by the aid of a magnesium wire; it causes a large, luminous flame with copious fumes of aluminum chloride; and the greater part of the matter is ejected; in every case an extremely light substance, containing some metallic carbide remains at the bottom of the crucible.

Aluminum carbide is also produced when the metal is heated in a current of the votalilised vapor of a carbon chloride, e.g. the tetra-chloride.

V. In the preparation of carbide by the synthetical method, some aluminum nitride is always formed in the portions of the mass near the surface; in some preparations, imperfectly conducted, the central part of the crucible also contained nitride. In that case the decomposition of the carbide by water gives ammonia as well as methane, but this ammonia has a very characteristic odor of amine. It may be that in the presence of nitrogen, the carbide and the aluminum are capable of forming a carbamine decomposable by water with the production of amines.

M. Fichter* has, however, recently shown that aluminum carbide, heated in a current of nitrogen, yields a nitride, while carbon is set free. The re-action would be:

*Zeit. Anorg. Chem., Vol. LIV, 1907, p. 322.

$\frac{1}{2}C_3Al_4$ (sol.) $+ N_2$ (gas) $= 2\,AlN$ (sol.) $+ \frac{3}{2}C$ (sol.) $- 67.7$ Cal., which would be endothermic, if the heat of formation attained by the nitride, as determined by M. Fichter, is taken into account.

This reaction constitutes a system in which only solids and a gas are included, but as I have shown,* similar systems can only be realized in the sense of the transformation indicated by

$$\frac{1}{2}\,C_3Al_4 + N_2 \rightarrow\!\!\!\rightarrow 2\,AlN + \frac{3}{2}C.$$

when the heat of the re-action is positive and greater than a certain quantity variable with the nature of the gas. It must be concluded then either that the re-action is incorrect or that the thermic valuation corresponding to it contains a large error. It is a point which should be more closely examined.

VI. The preparation of Aluminum carbide, starting from the metal and carbon-chlorides, can be generalized whenever the metal has sufficient affinity for chlorine. In every case the product of the re-action will be a mixture of the metallic carbide and chloride, usually easy to separate by using organic solvents of the chloride which have no chemical action on the carbide.

In fact, if the heat of formation of the chlorides is examined, which gives an approximate measure of the affinity of the metals for chlorine, the following table is obtained:

2 K Cl	205.6 Cal.
Ca Cl_2	190.3 "
$\frac{2}{3}$ La Cl_3	175.3 "
Mg Cl_2	151.8 "
$\frac{2}{3}$ Al Cl_3	108. "
Zn Cl_2	97.4 "
Cd Cl_2	93.7 "
Fe Cl_2	82.2 "
Sn Cl_2	80.9 "
$\frac{1}{2}$ Si Cl_4	64.0 "
$\frac{1}{3}$ Bo Cl_3	59.4 "
$\frac{1}{2}$ C Cl_4	37.9 "
$\frac{1}{3}$ C_6 Cl_6	28.4 "

which enables us to foresee the decomposition of the carbon-chlorides by a large number of metals, with the simultaneous production of carbides. This production of carbide at low temperature

*See a memoir on this subject entitled "Conditions of the Possibility of Certain Reactions Forming Monovariant Systems," which will soon appear in the "Annales."

should undoubtedly permit of the production of new, unstable bodies at the temperature of the electric furnace. I intend to try this new method and later to divulge the results.

Hence it is evident that the metals in the first terms of the above list should give actually explosive re-actions with the carbon chlorides. For example, calcium will disengage with benzene perchloride an enormous quantity of heat, as

$$2\,Ca + \tfrac{1}{3}C_6Cl_6 = Ca\,C_2 + Ca\,Cl_2 + 168.2\ Cal.$$

If intimate mixtures are made of finely divided calcium or magnesium, with Julin's chloride, hexa-chloro-carbon, C_6Cl_6, these mixtures can be ignited by a magnesium wire and give an explosion or a shower of sparks. There only remains at the bottom of the crucible a small quantity of matter, which sets free acetylene on contact with water. Therefore, in the two cases there are formed calcium carbide and magnesium carbide, the latter mostly decomposed. It therefore becomes necessary to regulate these very violent reactions by slowly passing the vapors of a carbon chloride over the heated metal at the lowest possible temperature.

VII. It may be asked if the elements arranged in the same group as aluminum would not, like this last, combine easily with carbon. Carbon boride appears to be formed, so far as can be judged by its properties, with a very great disengagement of heat; but, on the other hand, its two constituents, boron and carbon, are bodies of great inertia in most of their reactions; nevertheless they are suitable for making the attempt of their synthesis by simply heating in a Perrot furnace. A certain number of rare metals belong to the same group; it would not be surprising if some of them should form carbides directly; I have, however, tried, unsuccessfully, to combine neodymium and carbon; with lanthanum there would be better chances for a successful issue.

Summarising, it is possible to obtain aluminum carbide under the following conditions:

1st. By heating an intimate mixture of the two elements in a Perrot furnace.

2nd. By inducting the combination of the metalloid and the metal in a mixture containing an excess of aluminum by means of an ignition cartridge.

3rd. By decomposing carbon chloride by aluminum.

This last reaction may be generalised.

(Stated meeting held Thursday, March 5, 1908.)

The Transformations of the Elements.

By Harry F. Keller, Member of the Institute.

The report some time ago that a famous chemist has succeeded in producing certain elements of low atomic weight from other elements of high atomic weight has aroused a widespread and profound interest in the old question, "Are the substances known as the chemical elements the ultimate constituents of matter; are they really incapable of resolution into still simpler substances?"

While there can be no doubt of the high scientific character and accuracy of the work of such investigators as Profs. Ramsay and Rutherford, it would seem that the sensational accounts of the results of their work that have appeared in newspapers and popular magazines have led to extravagant, if not altogether erroneous impressions as to what has actually been accomplished. As in many previous instances the modest and cautious statements of the discoverers have been distorted and exaggerated into the most absurd claims. Thus we hear of "the dream of the alchemists realized," and of the transmutation of the metals, the base into the precious, as a matter beyond dispute. To be sure, the market values of gold and silver have not suffered the slightest depreciation, nor do those who have any acquaintance with the advances in physical science entertain such wild fancies. It has seemed to me, however, that it might not be amiss at this time, even before an audience trained in chemical reasoning, to attempt a brief, albeit imperfect, review of the experimental evidence that has been gathered on what may be termed the atomic transformations of matter.

I would have it understood at the outset that it is not my

purpose either to consider exhaustively the very extensive literature on the subject, or to attempt drawing any new conclusions from recearches of which only the first beginnings have been recorded by the master minds who are conducting them, of researches which, doubtless, will bring to light a multitude of facts that will guide us to a clearer understanding of the constitution of matter.

Let us begin, then, by inquiring as to the exact meaning of the word element, as it is now understood by chemists. Concisely stated, we regard as an element a substance out of which two or more essentially different substances have not been obtained, or as a substance which, though it may pass through numerous transformations, can always be recovered in its original form and in undiminished quantity from the compounds into which it enters. Take, for example, mercury. No one has yet succeeded in splitting up this substance into several distinct kinds of matter; and when we combine it with oxygen, with chlorine, or with sulphur, we can still extract the mercury as well as the other elements from the compound so produced, and the sum of their weights will be exactly equal in the weight of the compound. It is to the great philosopher, Robert Boyle, that we owe this conception. His famous work, the Sceptical Chymist, published in 1680, sounded the death knell to the Aristotelian doctrine of the Four Elements, earth, water, fire, and air, and of the Tria Prima—salt, sulphur and mercury—of the alchemists.

Boyle's arguments were based on observation and experiment, and his views of the "True Principles of Things" have been universally accepted for more than two centuries: our test of an element in its absolute homogeneity.

Up to the present day about eighty substances have been discovered which seemed to possess this characteristic. That it is by no means an easy matter to demonstrate this for an hitherto unknown substance, is abundantly borne out by the story of the discovery of our elements. New elements have been frequently announced, only to be placed on the now very long list of defunct ones. Time and again the supposed new element has turned out to be one already recognized, but masquerading under a new garb or contaminated with impurities. In spite of all the splendid analytical work done by American chemists, the discovery of a new element is an honor that we still have to wish for our country.

From time to time it has been claimed that certain of the recognized elements could be resolved into simpler substances; but when the supposed cleavage products were more carefully examined as to their chemical reactions, atomic weights, spectra, etc., it was invariably found that some blunder had been committed.

Nevertheless, the belief that our elements can be resolved into a primordial substance has survived even among chemists, and it would be quite an interesting, if laborious, undertaking to collect from the writings of scientists, philosophers and poets, the various expressions of opinion on this point, from Boyle down to the present day. A number of such quotations were given by Prof. Crookes in his interesting lecture on "The Genesis of the Elements." As a rule, however, they were visions that sprang from metaphysical speculations; in many cases, too, they were merely the survival of the alchemistic doctrine of the transmutability of metals.

Thus we read in the Sceptical Chymist, "men will never be able to explain the phenomena of nature, while they endeavor to deduce them only from the presence and proportions of such and such ingredients, and consider such ingredients or elements as bodies in a state of rest; whereas indeed the greatest part of the affections of matter, and consequently the phenomena of nature, seem to depend upon the motion and contrivance of the small parts of bodies."

And Faraday, in a course of lectures on the metals, held in 1818, made this remarkable statement, "to decompose the metals, then to reform them, to change them from one to another, and to realize the once absurd notion of transmutation, are the problems now given the chemist for solution."

I have selected these passages not because I consider them as revealing any special prophetic power on the part of their authors, but rather on account of the new meaning we can read into them in the light of the recent developments in physical science. They might indeed have been suggested by the discoveries of which it is my object this evening to give you an account.

This new chapter in the History of Physical Science may be said to begin with the observation of Henri Bequerel, in 1896, that phosphorescent uranium compounds, as well as the metal itself, have the property of acting upon photographic plates, even after they had for a long time been kept in a dark room. It was

further noticed that the rays emitted by these substances penetrated through opaque bodies, such as black paper, and, like the X-rays, had the power of discharging electrified bodies placed near their source. Shortly afterwards it was shown by Mme. Curie that thorium and its compounds share these remarkable properties with radium, and further that the activity of the latter is not affected by its combination with other elements. Yet, in the case of uranium *minerals,* it was observed that their activity was considerably greater than the degree calculated from their uranium content, and hence Mme. Curie concluded that this excess could only be due to the presence of some unknown substance of superior activity, and she forthwith proceeded to search for it. A ton of uranium residues was placed at her disposal by the Austrian Government for this purpose. After a long and laborious search, in which she was guided by the indications of the electroscope, Mme. Curie succeeded in separating two extremely active substances from the residue. The one first discovered was separated with the bismuth of the ore, and given the name *polonium,* in honor of Poland, Mme. Curie's native country. The second active substance, or element, was separated with barium, and as it turned out to be still more active than polonium, it received the very appropriate name *radium.* The task of separating the latter from the barium presented enormous difficulties, but was finally accomplished, the radium being obtained in the form of its chloride. Although the amount of this salt, in the pure state, was very small, Mme Curie was able to characterize the new element by a determination of its atomic weight (it is 226.18, according to recent experiments), and by an examination of its spectrum, by Demarcay. This spectrum shows several very bright lines and resembles the spectra of the alkaline earth metals, which radium also closely approaches in its analytical behavior.

The metal has not been isolated, but there is no room for doubt that if it could be reduced, it would be found strongly active. The separation from barium is based upon the fractional crystallization of the chloride or bromide. It is estimated that a ton of the pitchblende from Joachimsthal contains less than .2 gms. of radium.

Since the discovery of polonium and radium a considerable number of substances emitting similar rays have been examined, and several active elements or bodies have been extracted from

them. While special names have been given to these substances, it remains to be shown that they are true elements. The property of emitting rays, like those of uranium or radium, it termed *radioactivity,* and substances possessing this property are said to be radioactive. Among the well-characterized radioactive elements we have uranium, thorium and radium; while polonium, actinium, emanium, radiotellurium, radiolead, and ironium are strongly radioactive bodies which have not been sufficiently studied to be placed on the list of elements.

The subject of radioactivity has been very ably discussed and illustrated in a lecture before the Institute by Drs. Bradbury and Partridge. They have shown you how this remarkable property may be detected and measured by its effects on the fluorescent screen, the photographic plate and the gold-leaf electroscope. The latter affords the most delicate method and the one now exclusively employed for quantitative tests, *i. e.,* for measuring the degree of radioactivity. To this end the electroscope is charged and the substance to be tested brought on the bottom of the case of the electroscope. The air within now suffers a change known as "ionization," which manifests itself by causing the discharge of the electrified body. Assuming the degree of this ionization to be proportional to the radioactivity of the substance under examination, the relative intensity of two radioactive substances can be ascertained by observing the rate of fall of the gold leaf.

One of the most interesting properties of certain radioactive substances of radium, thorium and actinium, for example, consists in that they continuously give off a gas, or emanation. This gas is radioactive and also differs in other respects from all other gases with which we are acquainted. The emanation rapidly disintegrates and is transformed into other substances. Only one of the products has been identified with a known element: Prof. Ramsay has shown that *helium* exists among the disintegration products of radio emanation.

The importance of this observation can hardly be overestimated, for it is the first recorded instance of the transformation of one well-defined element into another. The suggestion that helium might be a cleavage product of the radioelements was first made by Rutherford and Soddy, in 1902, and it was experimentally verified in the following year, when Ramsay and Soddy procured a specimen of a pure radium bromide, made by Giesel, and

examined the gas, which was given off on dissolving this salt in water. After removing the oxygen and hydrogen, they introduced the remaining bubble into a Pluecker tube and found that it gave the characteristic D3 line of helium. A repetition of the experiment with another specimen of radium bromide afforded even more conclusive results, in that the purified gas, on being sparked in the vacuum tube, showed the entire helium spectrum.

It may be well here to recall the interesting circumstances connected with the discovery of helium. The bright yellow line of its spectrum was first observed by Janssen and Lockyer, in 1868, when these astronomers examined the chromosphere of the sun. As it did not coincide with any line in the spectra of the then known terrestrial elements, it was assumed to belong to a new element, for which Lockyer proposed the name helium. The yellow line, as well as others that were found to accompany it, was also noticed in the spectra of many stars, but it was not until 1895 that helium was discovered as a terrestrial element, and found to be a gas resembling argon. This gas has been previously extracted from cleveite, a variety of pitchblende, by Dr. Hillebrand of Washington, but remained unrecognized until it was purified and carefully studied by Ramsay, and independently by Langlet, of Upsala. Since then it has been found rather widely distributed; it is present in many minerals containing uranium and thorium, in fergusonite, in the gases of certain mineral springs, and, in traces, among the gases of the atmosphere. It is characterized by its low specific gravity (two compared with hydrogen), and by a brilliant spectrum which contains besides the yellow line a number of others in the red, green, blue and violet. Like argon, it is inert and monatomic.

When Ramsay and Soddy first published their discovery that helium is a product of the disintegration of the radium emanation, many scientists were inclined to doubt the correctness of their observations, or, at least, of their interpretation of the results. But the formation of helium from radium has since been abundantly confirmed by other investigators, and what appears to be conclusive evidence has been secured to show that the helium was not originally present, or occluded, in the radium bromide.

Thus Ramsay and Soddy collected the emanation from 60 mg of the bromide, condensed or liquefied it by means of liquid air (a process first employed by Rutherford to separate other gases from

the thorium emanation), and pumped out the gaseous admixtures. The emanation was then volatilized and transferred to a diminutive Pluecker tube. At first not the slightest indication of helium could be obtained, but after three days the brilliant yellow line appeared, and a few days later the entire spectrum of helium was distinctly visible. This left no doubt as to the source of the helium.

To show that helium gas is directly produced by the atomic transformation of radium, Curie and Dewar have made a most convincing experiment; they placed a considerable quantity of radium chloride into a quartz tube, heated the salt until it was fused, and evacuated the tube. After the emanation and other gases had thus been removed, the tube was sealed. A month later it was found by the spectroscopic test that the tube contained helium.

It is interesting to note that helium has also been obtained from actinium preparations.

An enormous amount of experimental work has been done to ascertain the exact nature and origin of the radioactive emanations, but owing to the extremely minute amount and the unstable character of these gases, their investigation has been attended with the greatest difficulties.

That they are gases may be inferred from the fact that they mix with air, and when so mixed retain their power of ionizing the air, so that the latter will discharge an electroscope. Both the emanations from thorium and radium are condensable at temperatures below 154° C. The emanations of thorium and actinium are too short-lived to be collected and measured, but the radium emanation, whose rate of decomposition is very much slower, has been obtained apparently free from other gases. And while it has not been possible to ascertain its exact density, it is estimated that the latter cannot be far from 100. We shall presently see that in all probability the emanation belongs to the helium group, or inert gases, whose atomic weights are equal to twice their densities. Ramsay has indeed thrown out the suggestion that the radium gas may have an atomic weight of 216.5, and thus fill the gap after xenon in the periodic table. The only kind of rays emitted by the radium gas are the alpha rays.

Towards chemical agents the emanations, both of thorium and radium, behave like the inert gases of the atmosphere. At a red

heat they remain unchanged when brought in contact with substances like oxide of copper, zinc dust, magnesia-lime mixture, or platinum black and oxygen. Neither are they affected when sparked with oxygen in the presence of caustic alkali. Prof. Ramsay has also found that the radium emanation has a definite spectrum, which he describes as very brilliant and as consisting of a number of well-defined lines, like the spectra of the helium family.

But in one respect the emanation is wholly unlike the other gases with which we are familiar. As already stated it is not permanent, and undergoes a rapid disintgeration, attended with the expulsion of alpha-particles and the formation of non-gaseous but radioactive substances which condense on the surface of negatively-charged bodies.

The presence or absence of such radioactive deposits can only be detected by their power of ionizing air. By highly ingenious methods, it has been possible to determine the law according to which the transformation takes place, and which, as Ramsay puts it, "may be likened to the inverse of the law of compound interest." The average life of the particle of radium emanation has thus been estimated to be five days and nine hours.

Despite the fact that the radium emanation must be classed with the inert gases, it is the most powerful chemical agent known. Weight for weight, it is said to be 100,000 times as active as radium itself; it glows in the dark and, according to Prof. Ramsay, evolves about three million times as much heat as is produced by the explosion of a like volume of a mixture of two volumes of hydrogen and one of oxygen.

There can be no doubt, then, that this emanation should effect chemical changes which have hitherto remained unknown, and in view of what has been said it would not, perhaps, be very surprising to us if we were told that substances hitherto regarded as elements had been "degraded," *i. e.*, resolved into simpler substances, or had been converted into other known elements.

I shall now endeavor to present to you some of the very remarkable observations in this direction which have recently been published by Sir William Ramsay and his collaborators. Their researches concern the action of the radium emanation upon water and upon solutions of certain metallic salts. This work is still in progress, in fact it has hardly passed beyond the stage of a

preliminary survey; yet the facts already brought to light, and the hypotheses suggested by them, seem calculated to shake the very foundations of physical science.

While the radium salts give off but little of the emanation when placed in a dry atmosphere, the transformation-product may be liberated either by heating or by dissolving the salts in water. In the latter case gas is evolved to the extent of say ten c.c. per gramme of radium per day. This gas consists chiefly of a mixture of oxygen and hydrogen, but invariably contains an appreciable excess (of several per cent.) of the latter. Admixed to these gases is a very small proportion of the emanation.

There can be no question that the oxygen and hydrogen are produced by the decomposition of water, but it is difficult to account for the excess of hydrogen; a number of suppositions as to the cause of this have been made, but none of them has stood the test of experimental inquiry.

Thus an interesting experiment was made to ascertain what action the radium emanation might have upon mixtures of oxygen and hydrogen. The gas obtained from a solution of radium bromide was divided into equal parts; one-half was exploded in the burette and it left a residue corresponding to 5.64 per cent. of hydrogen; the other half was sealed up and kept for three weeks, when it was found to have contracted to about two-thirds of its original volume. Thirty per cent. of the gas had recombined, and when the residue was exploded, pure hydrogen to the amount of five per cent. of the original gas remained. This leads to the conclusion that the action of the emanation is a reversible one. The speed of the decomposition, however, must be greater than that of recombination, for otherwise the elements could not be liberated from the water. Thus far all attempts to measure the rate of the decomposition have proved unsuccessful.

Inasmuch as the emanation decomposes water practically in the same manner as the electric current, it occurred to Ramsay that it might also reduce a copper solution and deposit from the latter an amount of metal equivalent to the hydrogen. Contrary to expectations, however, not a particle of copper was precipitated. But when the copper was removed from the solution that had been treated with the emanation, the liquid was found to contain notable amounts of sodium and a trace of lithium. To see whether the presence of these alkali metals was due to the glass or

the materials employed, the experiment was repeated with elaborate precautions to ensure the exclusion of other metals; and blank experiments were also made in which the copper solution was not subjected to the action of the emanation, but otherwise treated in exactly the same way.

On account of the slow action of the emanation it was necessary to extend the experiment over weeks, and even months. A description of these highly interesting experiments may be found in a paper by Cameron and Ramsay, in the September number of the Journal of the Chemical Society. It may suffice here to indicate the most important facts. The copper sulphate or nitrate employed in the several experiments was most carefully purified, as were also the water and the reagents. In one of the experiments only gaseous reagents were used, and all apparatus, except the glass bulb in which the solution was treated with the emanation, were made of platinum or fused quartz. In this case equal parts of a copper nitrate solution were introduced into two bulbs made of the same glass tubing. One of these bulbs was sealed, while four "doses" of emanation were introduced, at intervals of several days, into the other which was then likewise sealed off.

The contents of the first bulb remained clear blue, but the solution treated with the emanation turned slightly turbid and assumed a green color. On being centrifuged in a quartz tube, it yielded 4.11 mg of solid residue. This was found to consist of a basic copper salt. The solution separated from the latter was freed from copper by means of hydrogen sulphide and evaporated. The residue weighed 1.67 mg and consisted chiefly of a sodium salt, with traces of calcium and lithium. Ramsay estimates the amount of lithium at .00037 mg.

The blank experiment yielded only .97 mg of residue, and while this gave the spectra of sodium and calcium, it was found to be entirely free from lithium.

Somewhat similar experiments were made with solutions of lead nitrate, but although the formation of minute quantities of "six-sided colorless tables, and reddish yellow grains" was noticed, after a treated solution of the nitrate had been freed from lead, this residue was too small to allow of further investigation. By using larger quantities of the emanation and substituting bulbs made of silica the authors hope to obtain, from both the copper and the lead solutions, such amounts of the products as will permit

them to arrive at more definite conclusions. Such experiments are now in progress, and it may be expected that they will yield most interesting results.

While popular attention and curiosity have been excited mainly, if not entirely, by the apparent transformation of the metals under the influence of the radioactive emanation, no less significant facts have been brought to light by the study of the gaseous products of this action.

The gases investigated by Ramsay and Cameron were the residues left after treating with emanation, in glass tubes, pure distilled water, and solutions of the nitrates of copper and lead.

The "copper gas" obtained by pumping out the bulb containing the treated solution of the nitrate, was found to contain considerable quantities of nitric oxide, which must have resulted from a reduction of the nitrate ion. This oxide of nitrogen, as well as the oxides of carbon, and the oxygen, hydrogen and nitrogen, were carefully removed, and their amounts determined. The analysis gave:

Nitric oxide	1.12 c.c.
Nitrogen	.34 "
Carbon dioxide	.27 "
Hydrogen	.44 "
Oxygen	1.12 "

The spectrum of the residue was that of pure argon. While this gas and the nitrogen may have leaked in through the stopcocks of the apparatus, Ramsay does not incline to this view, but believes that the nitrogen was derived from the nitrate and that the argon resulted from the "degradation" of the emanation.

The gas from the "treated" water was found to contain:

Nitrogen	.307 c.c.
Carbon dioxide	.065 "
Carbon monoxide	.030 "
Hydrogen	3.746 "
Oxygen	1.562 "

The residue left after the removal of these gases gave a brilliant spectrum in which every line of neon and some of the yellow and green lines of helium could be identified.

As to the gas extracted from the bulb in which lead nitrate had

been treated with emanation, it contained neither nitric oxide nor carbon monoxide, and it was not tested for inactive gases.

If we accept the idea that the radium emanation is a gaseous element of high atomic weight and belonging to the argon group, we may consider the production of helium, neon, and argon—the lower members of the series—to be due to the atomic disintegration or "degradation" of that element. This change would occur under circumstances which are totally different from those attending ordinary chemical action. It might be attributed to the spontaneous and explosive emission of alpha particles from the radium, and the subsequent bombardment of the larger atoms of the emanation by these particles. Some hold that these particles are identical with helium, but Ramsay considers this improbable. Helium is formed when the emanation is left alone, or when it is mixed with oxygen and nitrogen. But when particles of greater mass than oxygen and hydrogen are present, the degradation does not proceed so far; in presence of molecules of liquid water it yields neon, and when the emanation acts upon still denser and more complex molecules, as in a solution of copper sulphate, argon is produced. At the same time, it would appear, the heavier atoms that come into collision with the alpha particles likewise succumb to their disrupting power. Thus the copper ions in the sulphate solution appear to be slowly transformed into the lighter atoms of the alkali metals, sodium and lithium.

Another most remarkable observation of this kind is that an acid solution of thorium nitrate continuously gives off carbon dioxide gas.

No experimental evidence can yet be adduced to show that the transformations of the elements are reversible processes; we know of no case in which the heavier atoms have been built up from lighter and more elementary ones. The "dream of the alchemists" of the transformation of the base into noble metals has not been realized.

Nevertheless, it does not appear unreasonable to suppose that there may be conditions under which the radioactive elements of high atomic weight, are formed from elements of smaller atomic weight. On the supposition that radium, and perhaps bismuth and lead, result from uranium and thorium by the loss of definite amounts of helium—which some believe to be identical with the

alpha-particles—it might be argued that these elements could also be built up by the addition to the radium atom of the requisite number of helium atoms. According to Rutherford, "it thus appears that helium plays a most important part in the constitution of the radioelements, and it is not unlikely that helium as well as hydrogen may ultimately prove one of the more elementary units of which the heavy atoms are built up."

With this, however, we enter the field of speculation.

The application of radioactivity to the solution of chemical problems is still in its beginnings, but I think there can be no doubt that we are on the threshold of a new period in the history of our science, a period inaugurated by what Landolt has recently pronounced "the most remarkable chemical discovery since the true nature of combustion was established"—the radioactive transformation of one elementary substance into another.

I have endeavored to confine my account to the purely chemical side of the subject, and have purposely refrained from a discussion of the probable causes and the mechanism of atomic distegration. If I have succeeded in piloting you to the most prominent points of interest in this new field of chemical research, my object is fully accomplished.

At the close of the lecture a number of slides were shown illustrating the history of the subject and the apparatus employed by the investigators.

WHITE FIR AS PULP WOOD.

On the Pacific Coast, especially in Oregon and California, there is an immense amount of white fir *(Abies concolor)* timber now going to waste for lack of some commercial profitable means of disposing of it. At present it is very little used for lumber, and since it is not cut to any extent its proportion in the forest tends to increase at the expense of other and more valuable trees.

Experiments conducted at the Forest Service laboratory at Washington show that this wood is admirably adapted for the production of paper pulp by the sulphite process. The wood is found to yield very readily to the action of the sulphite liquors used, which is of the usual commercial strength, viz.: about 4.0 per cent. total sulphur dioxide, 1.0 per cent. combined and 3.0 per cent. available. The length of treatment has varied, in the different tests, from eight to ten hours, and the steam pressure from 60 to 75 pounds. These pressures correspond to maximum temperatures of 153 to 160 degrees C.

The pulp produced in these experiments is from nearly white to light brown in color, according to the variations in the method of cooking, and by selecting the proper conditions of treatment it would be readily possible to produce a grade of fibre which could be used in many kinds of paper without the least bleaching. If, however, it is desired to employ the fibre for white book or writing papers it could be readily bleached to a good white color. Results of laboratory tests show that the bleach required to bring the fibre up to the usual color for bleached sulphite spruce fibre is from 15 to 23 per cent. to the weight of unbleached fibre; that is, assuming the bleaching powder to contain 35 per cent. available chlorine. Sulphite spruce fibre now on the market requires from 175 to 500 pounds of 35 per cent. bleach per ton of product or from 9 to 24 per cent. of the unbleached fibre. It is seen, therefore, that so far as bleaching is concerned the pulp made from white fir is just as good as that made from spruce.

The yields obtained in these experiments ranged from 43 to 49 per cent. on the bone dry basis. This is exclusive of screenings which in no case exceed 1¾ per cent. of the dry wood used. From careful observation of the methods employed in determining the yields it seems probable that those figures will be increased slightly when larger quantities of wood are used and it is believed that in the matter of yield the fir wood is fully equal to spruce.

The fibre from these cooks is in most cases light colored and somewhat lustrous and the sheets formed from it without any beating are remarkably tough and strong. Microscopic examination and measurements show that the fibre are of very remarkable length, being from one-half to two-thirds as long again as the commercial sulphite spruce fibre.

It is believed from the results that, so far as the product is concerned, the manufacture of fibre from white fir would be a commercial success and that the fibre produced would find its greatest usefulness in the production of manilas where great strength is required and in tissues which need very long fibres. It seems probable, also, that it would make very good newspaper for which purpose its naturally light color would particularly adapt it.

CONGRESS OF REFRIGERATING INDUSTRIES.

The First International Congress of the Refrigerating Industries is to be held in Paris, France, October 5 to 10, 1908, under the patronage of the French Minister of Agriculture, Commerce and Industries.

The purpose of the Congress is to bring together the leading experts and representatives of the different industries and enterprises of all countries in which refrigeration is used as an agent for facilitating the preservation and transportation of food products by land or sea. It is believed that such a Congress will be likely to stimulate the best thought in the world on the subject of refrigeration, and through such a conference of practical and scientific men it is hoped to improve and perfect the production and application of mechanical refrigeration.

The topics to be considered by the Congress are as follows: Low temperatures and their general effects; refrigerating appliances; the application of refrigeration to food; the application of refrigeration to other industries; application of refrigeration in commerce and trantport; and legislation.

(Stated meeting held Thursday, March 5, 1908.)

New Aids For Navigation.*

HENRY EMERSON WETHERILL, M.D.

Lt. Surg., and Inspector of Rifle Practice, "Naval Force of Pennsylvania." Candidate for Master Mariner, U. S.

A Special Semicircle, Called Angleometer.—Having but one reflector which serves both as index and horizon glass, this instrument is free from the corrections accompanying the horizon glass of other instruments, can be made without scale yet accurate enough for meridional lunar declination for Greenwich time.

As the ray of light is reflected but once the luminosity for stellar observations is decidedly advantageous, thereby increasing three fold the number of stars that may be used. Approved by the best men, with whom I have consulted.

The special vernier reading to 170 degrees enables observations of heavenly bodies of high altitude, and with the artificial horizon.

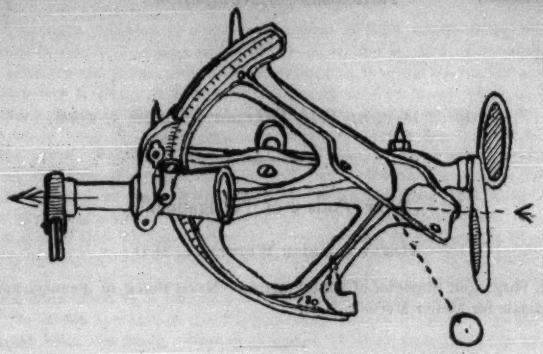
There being no parallax, as with other instruments, makes it good for land surveys, as in measurements of near-by objects.

The simplicity of construction and method of making the micrometer enables the instrument to be sold at a price one-third off the present instruments, and will be a boom to the American production of these instruments, now almost wholly made abroad.

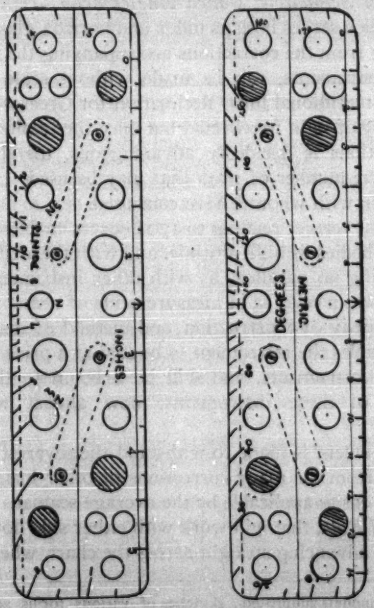
This instrument is made to withstand the severest service, and its freedom from the many corrections of other instruments renders it more easily applicable by the average seaman.

A Parallel Rule, that will work with either side down, and that is capable of advancing straight across the chart, whether the rule

*Working models submitted; sketches of various forms accompany this paper.



Angleometer.



Two-sided Parallel Rule.

is open or closed. It is thick enough to enable you to tip it in going over obstacles.

It is preferably made of seasoned, quartered, straight grained Santo Domingo mahogany, with the three pieces arranged with the grain in opposite positions, to prevent warping, and the bars set in the center of the rules. The screws are arranged to take up wear. The corners are rounded, and the rules peforated to enable you to see the chart, and for the insertion of pads to prevent slipping of the rule.

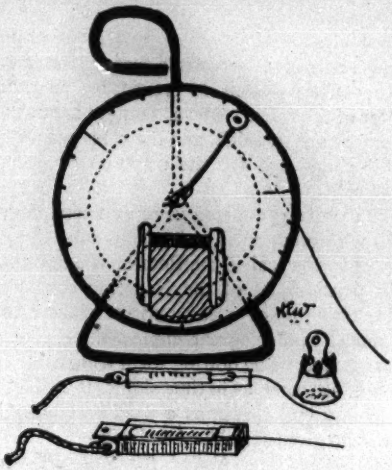
Metal edges may be graduated in centimeters, degrees, points, and inches, as with other rules, using both sides.

A Self-Inking Roller, called the Rotalin, is a disc that facilitates the inking or penciling in of the Naperian compass correction curve, or the drawing or measurement of any mathematical curve, boat model outline, great circle course, line on squared paper, or chart course. The dotting form will enable observations to the fraction of a second, as in time sights. It enables a better estimation of leeway and serves as a dead reckoning course corrector. One form gives ships' heel and roll.

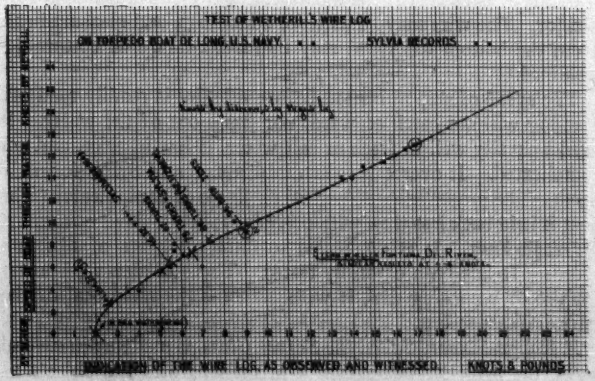
A Practical Speed Log, Called the Tafsped.—It has been found that accurate measurements of speed of ships can be made by towing a wire of sufficient length, flexibility, non-corrosibility, and diameter to have the pound dynamometer show knots. The instrument exhibited is the most perfected form of this speed indicator. The wire may be used for soundings, and measurements from the bottom for speed may be made, nature of bottom determined.

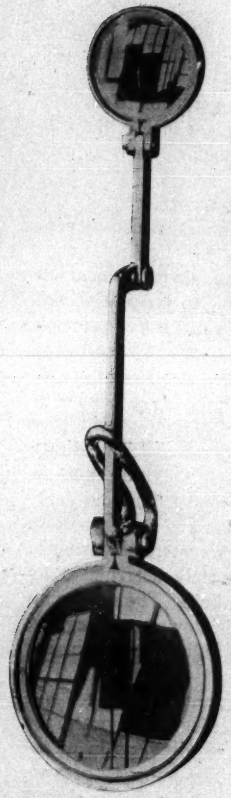
The speed of ship at instant before rifle fire is readily read off. The log will not catch seaweed, nor jump out of the water. It works equally well in fresh or salt water, is low in price, and not complicated. It overcomes the disadvantages of drags formerly tried. The propeller thrusts cause no jiggle of the indicator. The boat is held back less than with other logs; being about one pound for each knot. It is applicable to different boats of different speeds. It has been carefully tested. There is plenty of power for use of recording dial, if wished. It is the reciprocal of the taffrail distance log.

A Range-Finder, Called the Safper Glass, is made up in several ways, the principle being that a prism separates the objects as 1 is to 100 and a scale is used to measure the separation.

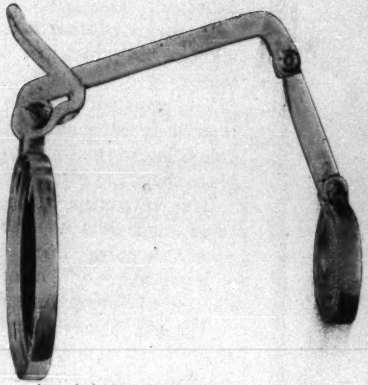


Wirs speed log.

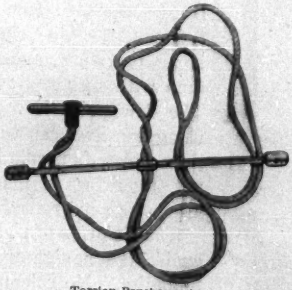

TEST OF WETHERILL'S WIRE LOG
ON TWIN-SCREW BOAT OF LONG U.S. NAVY. . . .
SYLVIA RECORDS . . .
INDICATION OF THE WIRE LOG, AS OBSERVED AND WITNESSED.
KNOTS & ROUNDS



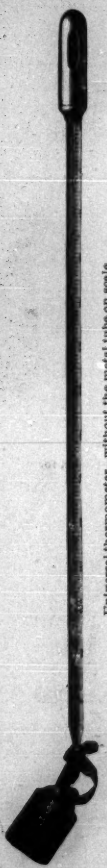
Pocket form of the 1 degree range glass. Achromatic combination is + 4D—20D. Power of 4.5 diam.



An early form of the range-finder—pocket form.



Torsion Psychrometer.



Universal thermometer—without the metal tube on scale.

This is the first application to the Galilean telescope, and a special pocket folding form is submitted. Now made to open up at once and into focus.

In rough weather the prism and scale are used without magnification, as in the telescope presented.

The great advantage is the application to any terrestrial or astronomical instrument *in use*, the ridicule being in the focus of the ocular. It is applicable to the prism glass.

This instrument keeps up its accuracy to any distance, and thus supersedes others which depend upon a short base line.

It will not get out of order, and does not have any delicate moving parts susceptible to jar of rifle fire.

The separation of the objects is a better principle than the use of stadia lines on objects of known size. Each glass has its own constant. A series of prisms may be used.

The Torsion Psychrometer submitted will give the maximum and minimum thermometer readings, being suspended free of the ship's motion, and on the cords that give the revolutions. Thus no gearing is necessary, and the results are more accurate than with such stationary hygrometers as Mason's. The dew point is more accurately determined by using the silver cap on the wet bulb. The maximum thermometer's needle is brought down centrifugally, not requiring a magnet. (Full description see Wetherill's hygromedry.)

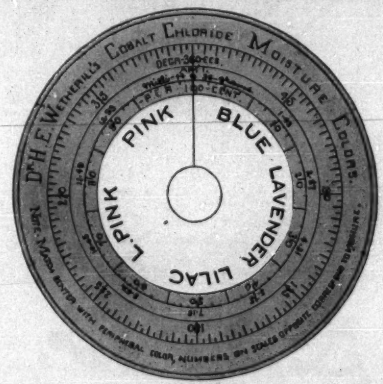
The Chloride of Cobalt Hygroscope exhibited will enable the navigator to rate his chronometer for humidity. No calculation is required, as in measuring the moisture of the air. The dampness of powder, and the atmosphere of the magazine is shown at a glance. It has been used for several years in allowing for the change of elevation of the rifle, with meteorological conditions. It would aid researches on the correction of the lower limb of sex-

tant angles, correcting for refraction there. (Ether from nitro powder no source of error.)

An instrument called the *Typwel* has been found advantageous in clearly showing the change of course due to the compass errors; it enables the compass adjuster to furnish a clear visible correction card. See cuts. Handy for insertions in manifest or bill of lading.

This typewriter will write seventeen words a minute, and in making headings for nautical computations to be kept in the special loose-leaf book submitted, it is advantageous.

It is vest-pocket size, and makes clear entries in the log, and tabulates in any square of the paper desired. It will make nota-



Cobalt Hygroscope dial.

tions on any sized charts and labelling the end of the charts with it facilitates the withdrawal of the chart desired from the special chart case shown. Music type shown, and cards of arrangement of letters exhibited. It will stencil phonetic Japanese.

The Celluloid Protractor Position Finder is a more practical method for the seaman to work the three or four point problems without the expense of cumbersomeness of other protractors. It will give the course, work a cross bearing, and protect the chart from rain.

It is a very large accurately scratched protractor, with radii so long that movable arms are unnecessary.

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Typwel letters

An early form, since much improved by slanting the letters, using a wire stem. Water refreshes the purple aniline reservoir. Letter spaces, interchangable for printing or translating cryptograms.

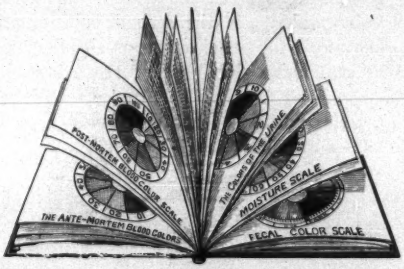
Arrangement of characters in the order of their use, which also helps solve cryptograms.

Arrangement of musical characters for the typwel in the order of their use. Can be placed on any line.

The graduations are filled with heel ball to make them visible. It is in one sheet and readily stows with the charts.

Sextant Attachments, as follows: Prism for adding constant angle for artificial horizon work in the tropics. Scale for locating a sextant, free from parallax thereof. Revolving stand for holding instrument. Glass level tube for finding horizon on land; new form with specially constricted tube.

The Artificial Horizon of glass, with base in the form shown, was found the very best way to use this method, and after trying various forms on different expeditions, it is found for an ordinary sun hour angle accurate to the fraction of a second of time. The bottom surface is specially ground and painted with a non-reflecting black. The three leveling corners having handles to the



Color scales.

screws show how much turning there is to get the desired effect upon the two large, reversible levels. This same surface reflection is used upon the angleometer, and obviates prismatic error of glass, and double reflection, as in the poorer principle of ordinary sextants.

The Light Measurer will enable an entrance in the log of the mathematical expression of the daylight. By counting the number of celluloids that will just prevent the determination between a black and a white cordan entry of the obscurity due to fog is made in the same manner as the instrument is made to express the lenticular opacity in opthalmology. In rifle work the gun pointer sights according to the light, naturally taking less front sight with more light, and this scale shows the amount of light. In a bright light nine celluloids are penetrated, and in ordinary office light only

four. It serves as a basis to work upon in estimating actinic power of light for the photographer of colors; a more compact and protected form for this purpose, recently marketed.

It is useful for keeping a record of light, as often at sea storms are preceded by less and less light. (See proceedings Pa. Bot. Soc., 1908, "Measurement of Light in Greenhouses.")

An aid to the use of Bowditch's tables is to have tabs with the number of the table on the edges of the pages.

The Horizontal Calipers shown have an enormous stretch for chart work and a scale upon them will show the extension. The limb can be clamped on either end of the slide groove, and the instrument can be worked with one hand.

The Scurvy test is the most accurate and practical Hemoglobin scale, and in the same book is bound the relative humidity scale, and other color scales. In the second edition, now going to press, is being added for naval surgeons all other color scales of use to them at sea. Hemoglobin scale corrected on all percentages at Panama.

I submit a table of decimal fractions of unity with logs to seven places, for use in calculations.

PRODUCTION OF MAGNESITE IN 1906.

All the magnesite produced in the United States comes from California, but the quantity is not large, since the consumption is small on the Pacific Coast, and the native product cannot compete at points of greatest consumption east of the Missouri River with that imported from Greece and Austria, owing to prohibitive freight rates from California.

The deposits at Porterville, Tulare County, yield most of the crude and calcined material, though a few thousand tons are derived from the Red Mountain deposits in Alameda County. Some calcined material is also sold by the manufacturers of carbonic acid gas, who, however, obtain their crude magnesite from the Porterville deposits. At Porterville there are kilns where the calcining is done. The calcined material is mainly used as a digester for wood pulp in paper manufacture. For carbonic acid gas manufacture about 800 tons are consumed yearly. The crude magnesite costs in the San Joaquin Valley about $3 a ton, and the freight to San Francisco Bay is $3 a ton. The calcined product sells for a lower price than formerly; at San Francisco it brings $14 per ton f.o.b. Higher prices for labor and mining now add about $1 per ton to the cost of the crude material. The calcined magnesite varies in price according to the amount of roasting given it, and that specially calcined and given a longer roast at a

higher temperature brings a higher price than that resulting from the manufacture of carbonic acid gas.

The total domestic output of crude magnesite in 1906 was 7805 short tons, valued at $23,415, an average of $3 per ton, as against 3933 short tons, valued at $15,221, in 1905. Most of this was roasted, resulting in 2864 tons of calcined magnesite for use as a digester of wood pulp and for making brick and building material. It usually requires 2.4 tons of raw magnesite ($MgCO_3$) to make 1 ton of calcined magnesite (MgO). This 2864 tons of calcined material was valued at $40,000, or between $13 and $14 per ton. Small lots were, however, sold at lower prices.

The imports of magnesite into the United States in 1906, including crude and calcined material and medicinal magnesite, amounted to 186,692,947 pounds, valued at $807,497, figures which represent substantial increases over those for 1905. The United States Consul at Vienna, Austria, states that the exports of calcined magnesite to the United States from the Vienna Consular district alone amounted to 53,000 tons, net weight, and that the principal company operating the magnesite mines in Austria is enjoying extraordinary prosperity.

A report on the production of magnesite in 1906, prepared by Charles G. Yale, is published by the United States Geological Survey as an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," which is n w ready for distribution.

INVESTIGATIONS OF COAL FIELDS.

The coal fields of thirteen States and Territories were examined by geologists of the United States Geological Survey in 1906, and the results of this work have just been published by the Survey as Bull tin No. 316, which forms Part II of "Contributions to Economic Geology, 1906."

The importance of the coal industry at the present time is well illustrated by a comparison of the values of the leading mineral products of the United States for the year 1906.

VALUES OF SIX OF THE LEADING MINERAL PRODUCTS OF THE UNITED STATES IN 1906.

Coal	$513,079,809
Iron	505,700,000
Copper	177,595,888
Clay products	161,032,722
Oil and Gas	137,318,667
Gold and Silver	132,630,200

So far as fuels are concerned the work of the Geological Survey is divided into three classes, geologic, technologic, and statistical, the last of which is in charge of the division of mineral resources, whose work for 1906 yielded the figures given above.

All the geological work on mineral fuels of the United States is under the general supervision of Mr. M. R. Campbell. The work is of various grades and degrees of precision, depending on the needs of the public and the conditions under which the surveys are carried on.

DECIMALS OF UNITY, PROCEEDING WITH A DIFFERENCE OF 1/128.

No.	Inch.	Decimal.	Logarithm.	Logarithm.	Decimal.	Inch.	No.
0	0	0	0	0	1.0	1.0	128
1	1/128	.007 812	7.892 7900	9.996 5905	.992 187	127/128	127
2	1/64	.015 625	8.193 8200	9.993 1584	.984 375	63/64	126
3	3/128	.023 437	8.369 9113	9.989 6989	.976 562	125/128	125
4	1/32	.031 250	8.494 8500	9.986 2117	.968 750	31/32	124
5	5/128	.039 062	8.591 7600	9.982 6918	.960 937	123/128	123
6	3/64	.046 875	8.670 9413	9.979 1476	.953 125	61/64	122
7	7/128	.054 687	8.737 8841	9.975 5743	.945 312	121/128	121
8	1/16	.062 500	8.795 8800	9.971 9713	.937 500	15/16	120
9	9/128	.070 312	8.847 0295	9.968 3335	.929 687	119/128	119
10	5/64	.078 125	8.892 7900	9.964 6697	.921 875	59/64	118
11	11/128	.085 937	8.934 1802	9.960 9747	.914 062	117/128	117
12	3/32	.093 748	8.971 9620	9.957 2480	.906 252	29/32	116
13	13/128	.101 560	9.006 7227	9.953 4842	.898 439	115/128	115
14	7/64	.109 373	9.038 8982	9.949 6924	.890 627	57/64	114
15	15/128	.117 185	9.068 8535	9.945 8672	.882 814	113/128	113
16	1/8	.124 998	9.096 8753	9.942 0081	.875 002	7/8	112
17	17/128	.132 810	9.123 2308	9.938 1093	.867 189	111/128	111
18	9/64	.140 623	9.148 0471	9.934 1802	.859 377	55/64	110
19	19/128	.148 435	9.171 5217	9.930 2153	.851 564	109/128	109
20	5/32	.156 248	9.193 7922	9.926 1211	.843 753	27/32	108
21	21/128	.164 060	9.215 0027	9.922 1699	.835 939	107/128	107
22	11/64	.171 873	9.235 2001	9.918 0933	.828 127	53/64	106
23	23/128	.179 685	9.254 4997	0.913 9780	.820 314	105/128	105
24	3/316	.187 498	9.272 9781	9.909 8234	.812 502	13/16	104
25	25/128	.195 310	9.290 7245	9.905 6232	.804 689	103/128	103
26	13/64	.203 123	9.307 7527	9.901 3875	.796 877	51/64	102
27	27/128	.210 935	9.324 1384	9.897 1100	.789 064	101/128	101
28	7/32	.218 748	9.339 9282	9.892 7900	.781 252	25/32	100
29	29/128	.226 560	9.355 1832	9.888 4210	.773 439	99/128	99
30	15/64	.234 373	9.369 9020	9.884 0133	.765 627	49/64	98
31	31/128	.242 185	9.384 1383	9.879 5603	.757 814	97/128	97
32	1/4	.249 998	9.397 9226	9.875 0613	.750 002	3/4	96
33	33/128	.257 810	9.411 2998	9.870 5092	.742 189	95/128	95
34	17/64	.265 623	9.424 2608	9.865 9149	.734 377	47/64	94
35	35/128	.273 435	9.436 8462	9.861 2715	.726 564	93/128	93
36	9/32	.281 248	9.449 0771	9.856 5779	.718 752	23/32	92
37	37/128	.289 060	9.460 9880	9.851 8268	.710 939	91/128	91
38	19/64	.296 873	9.472 5663	9.847 0295	.703 127	45/64	90
39	39/128	.304 685	9.483 8439	9.842 1785	.695 314	89/128	89
40	5/16	.312 498	9.494 8361	9.837 2727	.687 502	11/16	88
41	41/128	.320 310	9.505 5705	9.832 4323	.679 689	87/128	87
42	21/64	.328 123	9.516 0327	9.827 2852	.671 877	43/64	86
43	43/128	.335 935	9.526 2488	9.822 2073	.664 064	85/128	85
44	11/32	.343 748	9.536 2301	9.817 0693	.656 252	21/32	84
45	45/128	.351 560	9.545 9995	9.811 8631	.648 439	83/128	83
46	23/64	.359 373	9.555 5418	9.806 6005	.640 672	41/64	82
47	47/128	.367 185	9.564 8790	9.801 2733	.632 814	81/128	81
48	3/8	.374 998	9.574 0197	9.795 8800	.625 002	5/8	80
49	49/128	.382 810	9.582 9833	9.790 4118	.617 189	79/128	79
50	25/64	.390 623	9.591 7545	9.784 8811	.609 377	39/64	78
51	51/128	.398 435	9.600 3520	9.779 2790	.601 564	77/128	77
52	13/32	.406 248	9.608 7827	9.773 6036	.593 752	19/32	76
53	53/128	.414 060	9.617 0633	9.767 8457	.585 939	75/128	75
54	27/64	.421 873	9.625 1786	9.762 0180	.578 127	37/64	74
55	55/128	.429 685	9.633 1451	9.756 1110	.570 314	73/128	73
56	7/16	.437 498	9.640 9681	9.750 1225	.562 502	9/16	72
57	57/128	.445 310	9.648 6624	9.744 0425	.554 689	71/128	71
58	29/64	.453 123	9.656 3132	9.737 8841	.546 877	35/64	70
59	59/128	.460 935	9.663 6350	9.731 6371	.539 064	69/128	69
60	15/32	.468 748	9.670 9320	9.725 2989	.531 252	17/32	68
61	61/128	.476 560	9.678 1176	9.718 8586	.523 439	67/128	67
62	31/64	.484 373	9.685 1772	9.712 3298	.515 627	33/64	66
63	63/128	.492 185	9.692 1240	9.705 7012	.507 814	65/128	65
64	1/2	.500 000	9.698 9700	9.698 9700	.500 000	1/2	64

Constant difference of the decimals is 0.007 8125.

On one side of the table is the fraction, opposite is the amount to make it up to unity.

In multiplying fractions it is handier to use this table than to hunt up each item in a large logarithm table.

This table is founded on Baron Von Vega's mathematical tables.

The decimals were calculated to seven places, and then written down as six place decimals.

The use of an accurate decimal lessens the multiplication of an error.

In the region west of the 100th meridian the coal fields are comparatively unknown and the work of the Survey is largely exploratory. Rapid reconnaissance surveys are made over large areas to determine the limits of the field and to obtain such information regarding the number and character of the coal beds and their attitude as may be possible in the present undeveloped condition of the field and with the hasty method of examination. In the eastern fields information is needed almost as badly as in the West, but the work is of a much more detailed character and involves not only a thorough study of the geologic conditions under which the coal occurs, but also a study of the quality of the coal and its adaptability to various commercial uses.

The report just published covers results obtained wholly or in part during 1906 and includes 28 separate papers. Twenty-four of these describe coal fields in Pennsylvania, Kentucky, Virginia, Alabama, Illinois, Arkansas, Montana, Wyoming, Colorado, Utah, New Mexico, and California; three are papers of a general nature, and one—the last—is a list of the Survey publications on coal, lignite, and peat.

Bulletin No. 316 is now ready for distribution and may be obtained by applying to the Director, U. S. Geological Survey, Washington, D. C.

ENGELMANN SPRUCE AS A PULP WOOD.

Engelmann spruce is a comparatively small tree of rather slow growth whose range is on the high slopes of the interior mountain system from British Columbia southward to Arizona and New Mexico. Within this range it is used to some extent for lumber, mining timber, ties, and general construction, but it has not been considered a very valuable lumber tree, and it is employed only because of lack of better material. No estimate of the total amount of standing timber is available, but reports of stands show more than one and one-half billion board feet as occurring on four of the National Forests, and this is probably only a small part of the actual quantity standing. Throughout its entire range there is much material in the form of dead and mature timber.

The existence of such quantities of a wood of seemingly little value has induced the United States Forest Service to undertake experiments to determine whether this wood can be used for making paper pulp. Samples have been received from the National Forests of Wyoming, Colorado and Utah. These have been treated by the sulphite process, and a pulp has been obtained which, unbleached, is in color nearly as good as pulp made from Eastern spruce under similar conditions, and in strength, cleanliness, and other qualities seems to be fully as good. The results of preliminary trials on seasoned wood show that it cooks without difficulty and gives a yield of fibre nearly equal in volume to that from its eastern relative. The amount of screenings is very small, being between two and three per cent. Tests made on the fibre show that it bleaches quite easily, the amount of bleach varying with different cooks, but in general it may be said to require about the same quantities as fibre produced from Eastern spruce.

A few cooks have been made on green wood, cooked within two months

of the time the trees were cut, and the indications are that it will require a little higher temperature than the seasoned wood. The fibre produced from green wood, however, seems to be fully equal to that from seasoned wood, and is superior to it in color.

The fibre of Engelmann spruce seems to be slightly shorter than that from Eastern spruce, but it is of sufficient length to be used for the latter in nearly all the manufactured products, and there is apparently no reason why it should not be so used, provided the other conditions of manufacture and transportation are favorable.

Book Notices.

PUBLICATIONS RECEIVED.

Providence, R. I. Annual Report of City Engineer for the year 1907. 83 pages, illustrations, plates, maps, tables, 8-vo. Providence, City Printers, 1908.

U. S. Department of Agriculture:

Forest Service, Bulletin No. 77. Forest Products of the United States, 1906. 99 pages, tables, 8-vo. Washington, Government Printing Office, 1908.

Circular No. 143. The Relation of the Southern Appalachian Mountains to Inland Water Navigation, by M. O. Leighton and A. H. Horton. 38 pages, 8-vo. Washington, Government Printing Office, 1908.

Circular 144. The Relation of the Southern Appalachian Mountains to the Development of Water Power, by M. O. Leighton, M. R. Hall, and R. H. Bolster. 53 pages, 8-vo. Washington, Government Printing Office, 1908.

Complete classified index of Power Plant Equipment, including everything needed in engine and boiler rooms, power transmission systems and supplies, with addresses of manufacturers. Compiled from the advertising of live firms in "Power." 53 pages, 16-mo. New York, n. d.

Conservation of Historic Buildings and Frescoes, by Prof. A. H. Church. An address delivered before the Royal Institution of Great Britain, April 12, 1907 12 pages, 8-vo.

International Science, by Prof. Arthur Schuster. An address delivered before the Royal Institution of Great Britain, May 18, 1906. 22 pages, 8-vo.

L'Ébullition des Corps Simples. An address delivered before the Royal Institution of Great Britain by Prof. H. Moissan, June 1, 1906. 15 pages, illustrations, 8-vo.

Kurzes Lehrbuch der Organischen Chemie von William A. Noyes, Professor der Chemie an der Universität Illinois. Mit Genehmigung des Verfassers ins Deutsche übertragen von Walter Ostwald und mit einer Vorrede von Professor Wilhelm Ostwald. 722 pages, illustrations, 8-vo. Leipzig, Akademische Verlagsgesellschaft. m. b. H. 1907.

The present volume is a translation of Dr. Noyes' well-known "Text-

book of Organic Chemistry." The task of rendering it into German was undertaken by Walter Ostwald, who was able to secure the cöoperation of the author in the matter of improvements and corrections.

Only such changes were made as were found necessary to bring the book in accord with German practice. A subject-index of thirty-five pages makes the volume useful for general reference. A. R.

Penrose's Pictorial Annual. The Process Year Book for 1907-8, edited by William Gamble. An illustrated review of the graphic arts. 184 pages, illustrations, plates, quarto. London, A. W. Penrose & Co., Ltd. American agents, Tennant & Ward, New York. Price, cloth, $2.50.

The thirteenth annual issue of this interesting review indicates that work in the line of photo-engraving, lithography, color-printing, and related industries is still advancing.

There are included in the volume specimen illustrations of every branch of the reproductive processes, including two-, three-, and four-color prints, heliotypes, collotypes, wood cuts, and newspaper half-tones.

The text is made up of sixty-five articles, by various contributors, covering the subjects which are essential to the process worker.

R.

Hand-book of Mathematics for engineers and engineering students, by J. Claudel, from the seventh French edition. Translated and edited by Otis Allen Kenyon, New York. McGraw Publishing Co. 8-vo, cloth, 708 pages. Price, $3.50.

There are probably few actively engaged in the engineering profession who have not at some time felt the need of a reference book containing brief demonstrations of the mathematical theories involved in engineering investigations. Although general principles may be carried in mind and a required formula desired, neither the mathematical dexterity nor the time needed is always available.

Claudel's hand-book meets this condition by presenting in one volume a concise and lucid development of the mathematical processes usually employed by the engineer under the conventional headings, arithmetic, algebra, geometry (plane and solid), trigonometry (plane and spherical), analytical geometry and calculus.

The explanations, though brief, are full enough to make it valuable for systematic reading, as well as a most useful time-saving device in the drawing office or designing department of an engineering establishment.

For the latter class of users smaller type would have made it a more convenient size. L. E. P.